SOIL SURVEY OF

Riley County and Part of Geary County, Kansas

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

Major fieldwork for this soil survey was done in the period 1961–68. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the survey area in 1968. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Riley County Conservation District.

Either enlarged or reduced copies of the printed soil map can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All of the soils of the survey area are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

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

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described and the capability unit, range site, woodland suitability group, and windbreak suitability group in which the soil has been placed.

Individual colored maps showing the relative suitability of limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils in the soil descriptions and in the discussions of the interpretative groupings.

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

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Fish and Wildlife Management."

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

Community planners and others concerned with suburban development can read about the soil properties that affect the choice of homesites, industrial sites, schools, and parks in the section "Engineering Uses of Soils."

Engineers and builders will find, under "Engineering Uses of Soils," tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

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

Newcomers in the survey area may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the Survey Area," which gives additional information about the survey area.

Cover picture: A typical landscape in the survey area. The excellent crop of wheat is growing on Haynie very fine sandy loam, the trees are on Stony steep land, and the range is on Benfield-Florence complex, 5 to 20 percent slopes.

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SOIL SURVEY OF RILEY COUNTY AND PART OF GEARY COUNTY, KANSAS

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

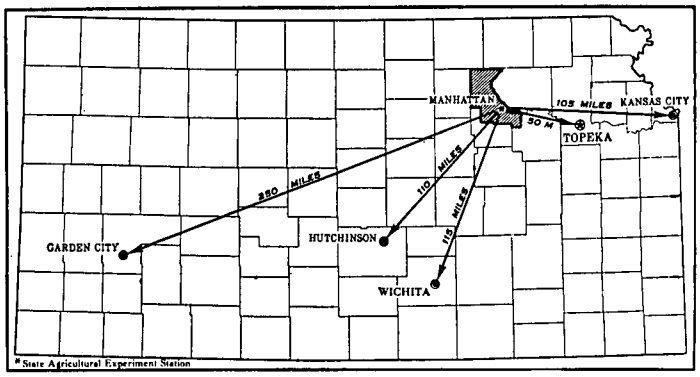

Figure 1.—Location of Riley County in Kansas.

RILEY COUNTY AND PART OF GEARY COUNTY are in the northeastern part of Kansas (fig. 1). Riley County has a total land area of about 611 square miles, or 390,824 acres. The survey area includes about 9,000 acres of Geary County that were not included in the soil survey of Geary County. The area in Geary County is adjacent to the southern boundary of Riley County.

In 1965, the population of Riley County was about 46,500 and that of Manhattan, the county seat, was 22,716. The stable economy of the county is based on farming and on services for Kansas State University and the Fort Riley military installation.

About 70 percent of the land area in Riley County is used for farming. Slightly more than 50 percent of the farmland is used for range, and nearly 40 percent is used for crops. Woodland, farmsteads, and other farm uses account for nearly 10 percent. Native range land consists mostly of mid and tall grasses. The most common crops grown in the survey area are wheat, grain sorghum, corn, and alfalfa. The Fort Riley Military Reservation occupies about 83,500 acres of Riley County and all of the 9,000 acres of Geary County that is in this survey. Tuttle Creek Reservoir covers about 5,000 acres in Riley County.

Most of the deep, arable soils of the uplands in the survey area are on high uplands in the western part of Riley County. These soils are nearly level to moderately sloping. The most important concern of management is the control of erosion. The soils in valleys along creeks and rivers are deep and generally are fertile. The main concern of management on these soils is the maintenance of fertility and good soil structure. The soils in broken, hilly areas are shallow and moderately deep. These soils generally are not suited to cultivated crops, and they are used mostly for range. Management is needed to maintain the grass in good condition.

How This Survey Was Made

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

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Irwin and Wymore, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such difference, a soil series is divided into phases. The name

of a soil phase indicates a feature that affects management. For example, Wymore silty clay loam, 1 to 4 percent slopes, is one of several phases within the Wymore series.

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

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of the survey area: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Benfield-Florence complex, 5 to 20 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Ivan and Kennebec silt loams is an example.

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

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

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

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map [1]

The general soil map at the back of this survey shows, in color, the soil associations in Riley County and part of Geary County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in an area, who want to compare different parts of an area, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, drainage, or other characteristics that affect management. The six soil associations in the survey area are described in the following paragraphs. Terms for texture used in the title of each association refer to the surface layer of the major soils.

1. *Eudora-Haynie-Sarpy association*

Deep, nearly level silt loams, very fine sandy loams, and loamy fine sands; on terraces and flood plains

This association is on the bottom lands along the Kansas, Republican, and Big Blue Rivers. In general, the more sandy soils occur on the lowest bottoms next to the river channels, and the soils that have a higher clay content are on the highest terraces farthest from the channels (fig. 2).

This association makes up about 7 percent of the survey area. It is 21 percent Eudora soils, 20 percent Haynie soils, 14 percent Sarpy soils, 11 percent Muir soils, and 9 percent Sutphen soils. Minor soils and river channels make up the remaining 25 percent.

Eudora soils are on terraces that are rarely flooded. They have a silt loam surface layer, about 10 inches thick, that is underlain by silt loam and very fine sandy loam. These soils are well drained.

Haynie soils are on the flood plains. They have a very fine sandy loam surface layer, about 10 inches thick, that is underlain by coarse silt loam and very fine sandy loam. Haynie soils are well drained.

Sarpy soils also are on the flood plains. They have a loamy fine sand surface layer that is about 5 inches thick and is underlain by fine sand. These soils are somewhat excessively drained.

[1] Tuttle Creek Reservoir on the general soil map makes up about 1 percent of the total survey area. It was not included with any soil association.

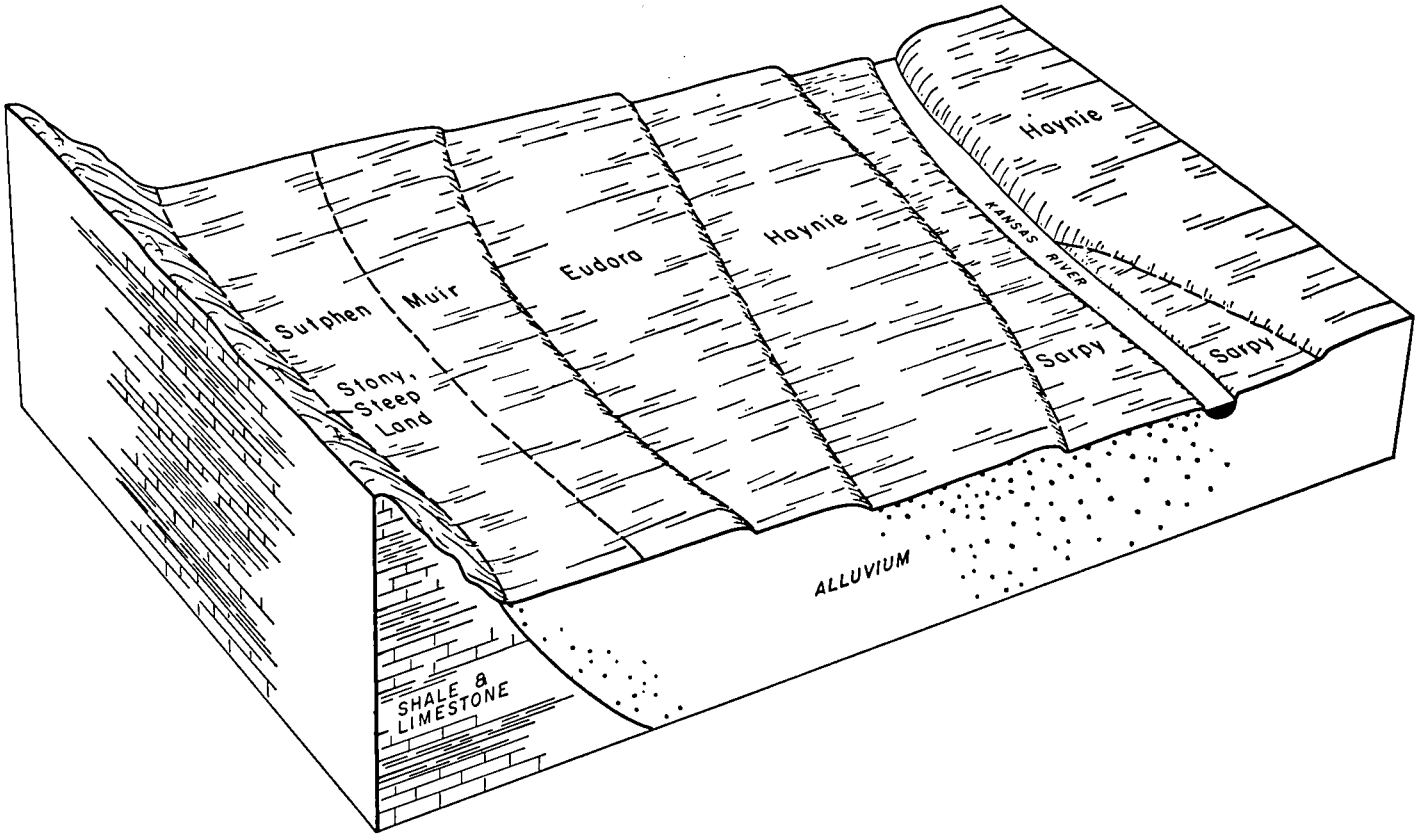

Figure 2.—**Major soils of the Eudora-Haynie-Sarpy association and their normal position on the landscape.**

The Muir and Sutphen soils are on terraces that are rarely flooded. Minor soils in this association are in the Carr, Chase, and Kahola series. Chase soils are on terraces, but Carr and Kahola soils are on flood plains.

Most of this association is cultivated. Wheat, grain sorghum, corn, and alfalfa are the most common crops, but some soybeans are grown in the association. Some garden and truck crops are grown on the Sarpy and Carr soils. A small amount of the association is irrigated.

In this association, soil management is primarily concerned with maintaining fertility and good soil tilth. Wetness limits the use of Chase and Sutphen soils.

Parts of this association adjoin the Carr-Sarpy association of Geary County. Eudora and Haynie soils are not in Geary County, and the Carr soils are not in Riley County, but the soils within the two associations are similar enough that their use and management are about the same.

2. *Reading-Kennebec-Ivan association*

Deep, nearly level and gently sloping silt loams; on terraces and flood plains

This association is on the bottom lands along Fancy, Wildcat, McDowell, and Deep Creeks. The bottom lands range from about one-fourth to 1 mile wide (fig. 3).

This association makes up about 4 percent of the survey area. It is 50 percent Reading soils and 27 percent Kennebec and Ivan soils. Minor soils and creek channels make up the remaining 23 percent.

Reading soils are nearly level and gently sloping and are in positions along the creek that are rarely flooded. These soils are well drained. They have a silt loam surface layer about 11 inches thick. The subsoil, about 41 inches thick, is silty clay loam. The underlying material also is silty clay loam.

Kennebec and Ivan soils are in the frequently flooded areas along the creeks. They are well drained to moderately well drained. Their surface layer is silt loam, 18 to 26 inches thick, that is underlain by silty clay loam.

The minor soils are mostly the Chase, Muir, and Tully.

Nearly all the acreage in this association is cultivated. Wheat, grain sorghum, corn, and alfalfa are the most common crops grown.

Soil management in the association is concerned chiefly with maintaining fertility and good tilth. Floods occasionally cause serious crop damage on the Ivan and Kennebec soils. Dikes are useful in some places to reduce flood damage.

Parts of this association adjoin the Tully-Muir-Hobbs association of Geary County. Both associations are in creek valleys, have similar use potentials, and require similar management. Reading soils of Riley County are similar to those Tully soils of Geary County that have a silty clay loam subsoil and the Muir soils that have a heavy silty clay loam subsoil. Ivan and Kennebec soils are not in Geary County, but they are similar to the Hobbs soils in that county.

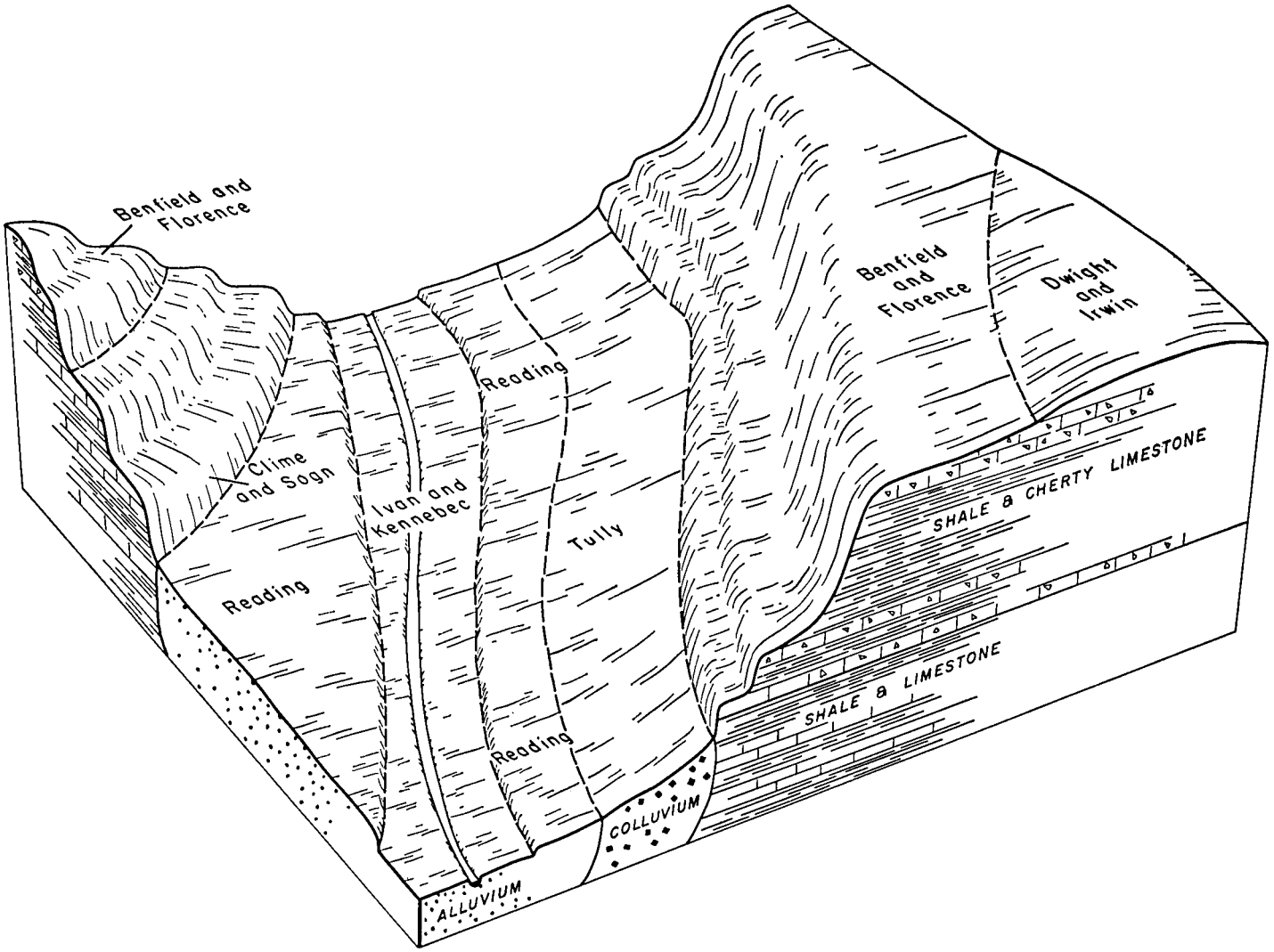

Figure 3.—**Major soils of the Reading-Kennebec-Ivan and the Benfield-Florence associations and their normal positions on the landscape.**

3. Smolan-Geary association

Deep, gently sloping and sloping silt loams and silty clay loams; on high terraces and uplands

This association is in five areas on high terraces and uplands on the north side of the Kansas River valley (fig. 4).

This association makes up about 4 percent of the survey area. It is 51 percent Smolan soils, 19 percent Geary soils, and 7 percent Wymore soils. Minor soils make up the remaining 23 percent.

Smolan soils are generally on that part of the terraces or uplands that is farthest from the river or tributary stream. These moderately well drained and well drained soils are gently sloping and sloping. They have a silt loam and silty clay loam surface layer about 9 inches thick. Their subsoil is silty clay loam.

Geary soils typically are on ridgetops and side slopes. They are a little lower in elevation and nearer to the river or tributary stream than the Smolan soils. Geary soils are gently sloping and sloping, and they are well drained. They have a silt loam surface layer, about 8 inches thick, and a silty clay loam subsoil about 34 inches thick. The underlying material is light silty clay loam.

Wymore soils are on the highest and broadest ridgetops in this association. They are moderately well drained and well drained, and they are gently sloping. These soils have a silty clay loam surface layer about 13 inches thick. The subsoil is mostly silty clay about 26 inches thick. The underlying material is silty clay loam.

Most of the acreage in minor soils consists of Kenesaw soils, which are lower in elevation and nearer the river than Geary soils. Also, there are areas of Clime, Sogn, Benfield, and Florence soils on the uplands and areas of Reading, Muir, Ivan, and Kennebec soils on the small bottom lands. Stony steep land also is in the association.

Much of this association is in the Fort Riley Military Reservation. Some is within the city limits of Manhattan and the developed areas around it. Only about 25 percent of the association is used for growing cultivated crops. Wheat, grain sorghum, alfalfa, soybeans, and corn are the most common crops grown.

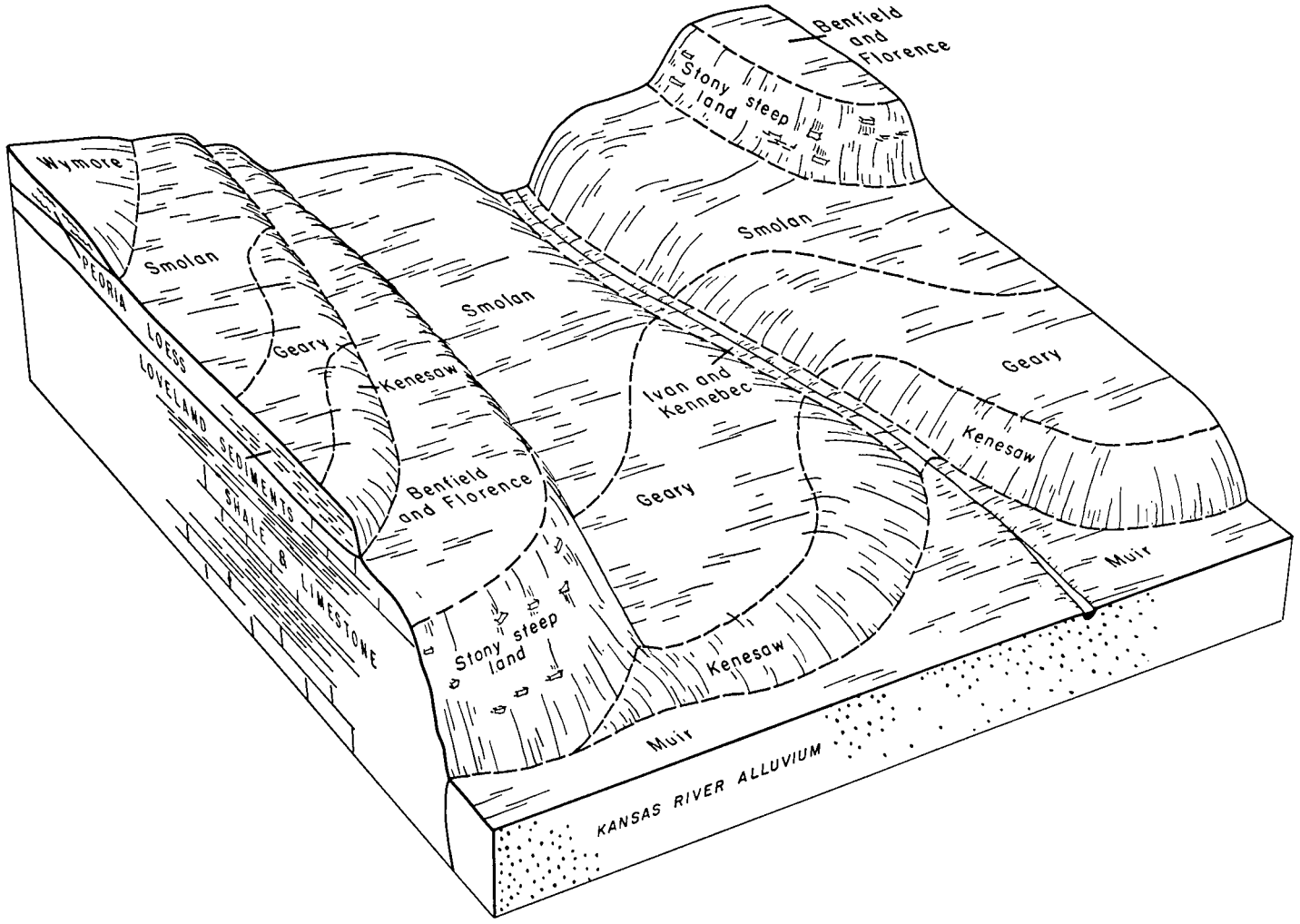

***Figure 4.*—Major soils of the Smolan-Geary association and their normal position on the landscape.**

Soil management in the association is concerned mainly with controlling water erosion.

Parts of this association adjoin the Hastings-Geary association of Geary County. Smolan soils are not in Geary County, and Hastings soils are not in Riley County; but the two associations have similar landscape features, have similar potentials for use, and require similar management.

4. Wymore-Irwin association

Deep, nearly level to sloping silty clay loams; on uplands

This association is on the high uplands, mainly in the western part of the survey area. It consists of nearly level and gently sloping soils in broad areas and of sloping soils in relatively narrow areas adjacent to intermittent drainageways (fig. 5).

This association makes up 45 percent of the survey area. It is 36 percent Wymore soils, 32 percent Irwin soils, and about 10 percent Clime and Sogn soils. Minor soils make up the remaining 22 percent of the association.

Wymore soils are on broad divides and ridgetops between drainageways. These soils are well drained to moderately well drained, and they are nearly level to sloping. These soils have a silty clay loam surface layer about 13 inches thick. The subsoil is mostly silty clay about 26 inches thick. The underlying material is silty clay loam.

Irwin soils are on ridgetops and side slopes adjacent to intermittent drainageways. They are slightly lower in elevation than the Wymore soils. Irwin soils are well drained to moderately well drained, and they are gently sloping and sloping. The surface layer is silty clay loam about 11 inches thick. The subsoil is silty clay about 39 inches thick. The underlying material also is silty clay.

Clime and Sogn soils are on short side slopes below the Irwin soils. Clime soils are sloping to moderately steep. They are silty clay loam about 30 inches thick over shale. Sogn soils are sloping. They have a silty clay loam surface layer that is about 9 inches thick over limestone bedrock.

Most of the acreage in minor soils consists of Dwight and Tully soils on uplands and Ivan, Kennebec, and Reading soils on small bottom lands.

Most of this association is cultivated. The most common crops are wheat, grain sorghum, and alfalfa. Some of the small areas on bottom lands are suited to corn. Range and

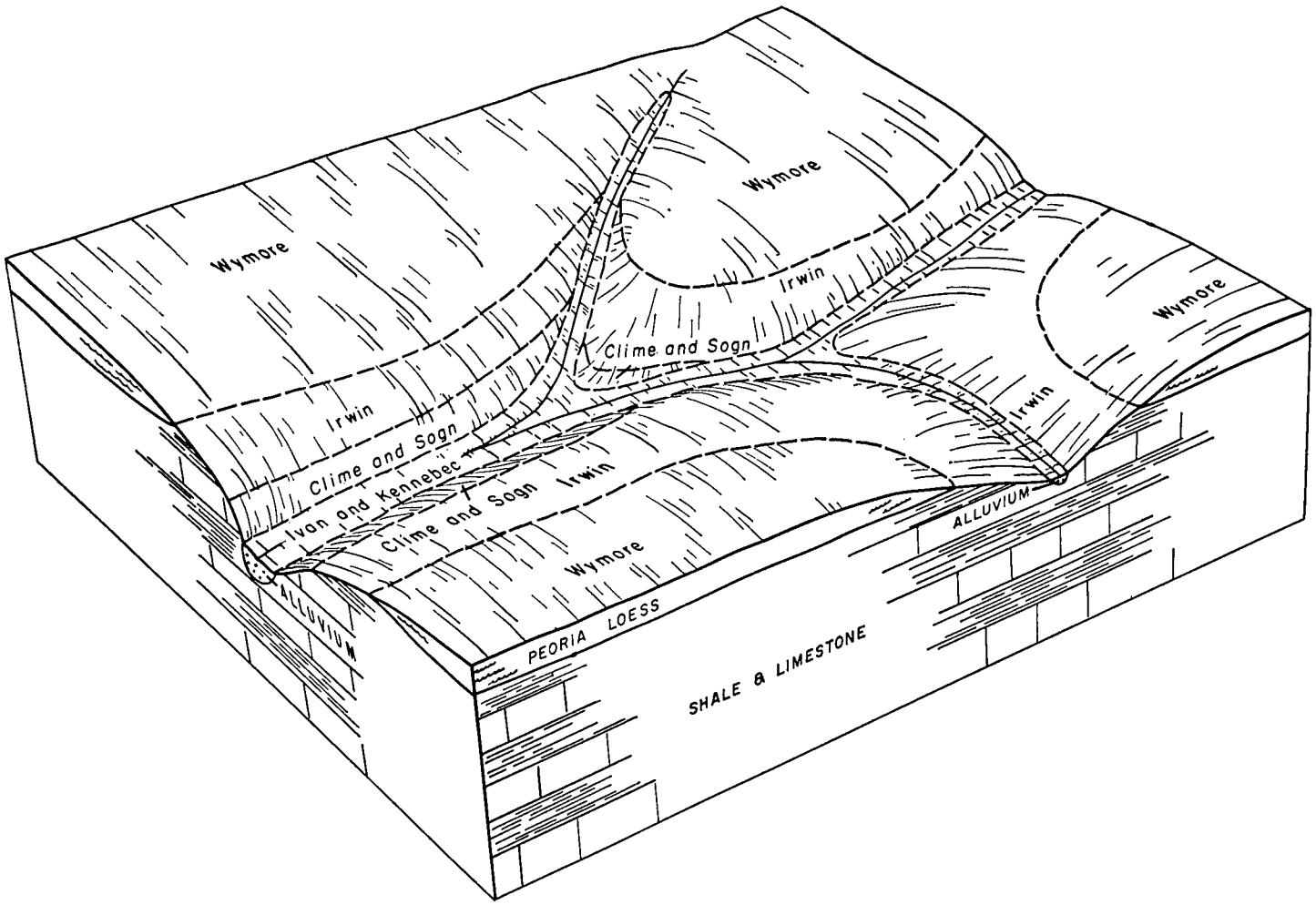

***Figure 5.*—Major soils of the Wymore-Irwin association and their normal position on the landscape.**

pasture areas are generally limited to the Clime and Sogn soils and the sloping Irwin soils.

Wymore and Irwin soils are droughty in dry periods. Controlling water erosion and maintaining soil fertility are the primary soil management concerns in this association.

Parts of this association adjoin the Crete association of Geary County. Crete soils are similar to Wymore soils. The two associations have similar landscape features, have similar potential for use, and require similar management.

5. Clime-Sogn association

Moderately deep and shallow, sloping and moderately steep silty clay loams; on uplands

This association is in several areas of the county, mainly in the eastern and southern parts. The association includes many deeply entrenched drainageways (fig. 6).

This association makes up 28 percent of the survey area. It is about 33 percent Clime soils, 19 percent Sogn soils, 13 percent Stony steep land, and 8 percent Tully soils. Minor soils make up the remaining 27 percent.

Clime and Sogn soils alternate in narrow bands that follow the contour of the slope. Clime soils are sloping to moderately steep. They are moderately deep and are moderately well drained and well drained. They have layers of silty clay loam and heavy silty clay loam throughout their profile. Shale having a silty clay texture is at a depth of about 30 inches.

Sogn soils are sloping, shallow, and somewhat excessively drained. They have a surface layer of silty clay loam that is about 9 inches thick. This layer is underlain by limestone bedrock.

Stony steep land is prominent on the valley walls along the sides of major stream valleys. The soils are steep. They are shallow and moderately deep and are excessively drained. The soil layers range from medium textured to fine textured.

Tully soils are on foot slopes and are gently sloping and sloping. These soils are deep and well drained. They have a silty clay loam surface layer about 10 inches thick. The subsoil is heavy silty clay loam or silty clay that extends to a depth of 51 inches. The substratum is silty clay.

Most of the acreage in minor soils consists of Irwin, Dwight, Benfield, Florence, Kennebec, and Ivan soils.

This association is mostly rangeland. Only the small areas of Tully, Irwin, Dwight, Ivan, and Kennebec soils

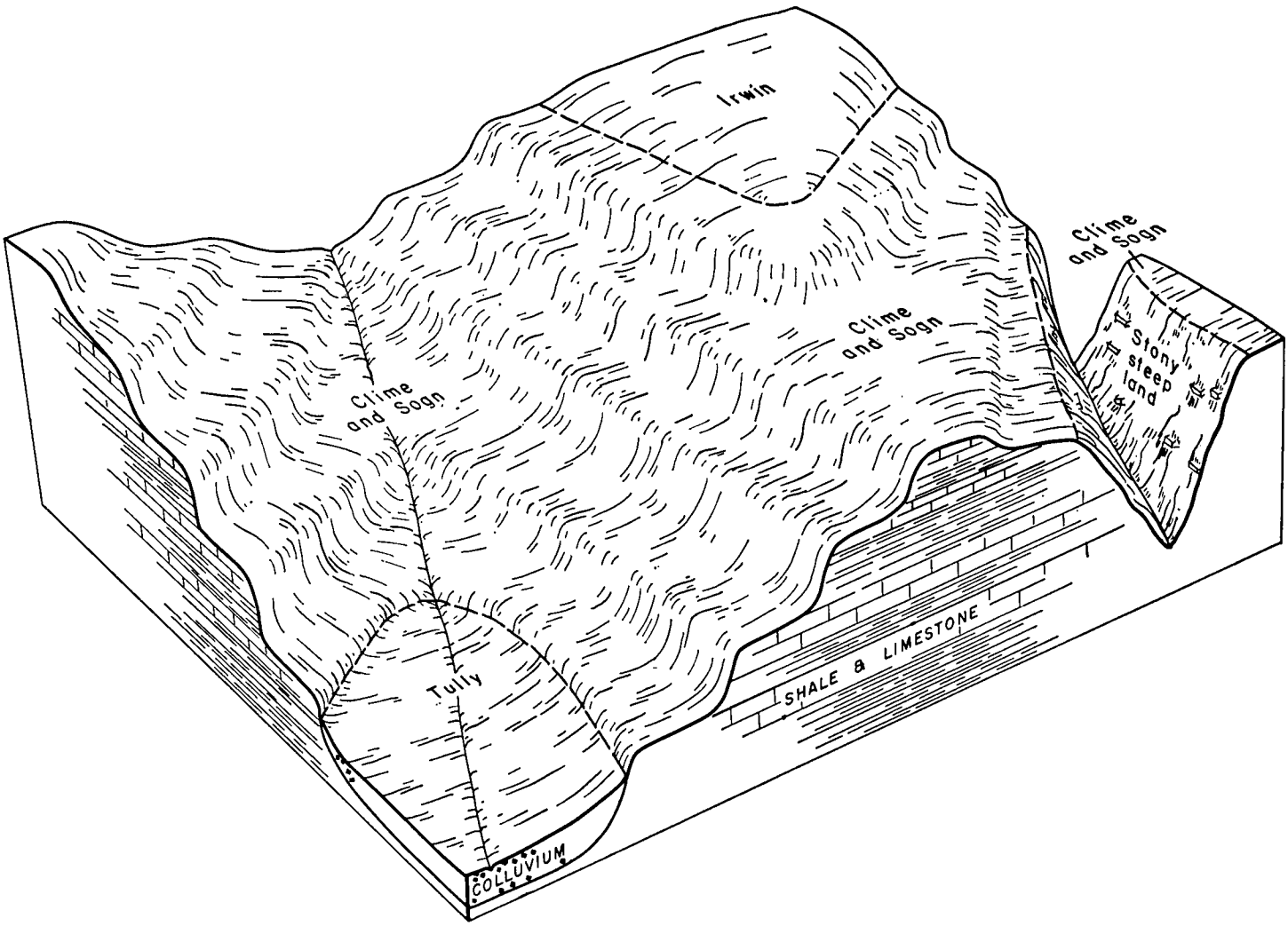

Figure 6.—**Major soils of the Clime-Sogn association and their normal position on the landscape.**

are suitable for cultivation. Management of the rangeland is primarily concerned with the maintenance of a good cover of mid and tall native grasses. Many areas require brush control.

Well water is difficult to locate in this association, but the terrain provides many good sites for farm ponds if suitable construction material is also available. The association includes many areas that are suitable sources of crushable limestone.

Parts of this association adjoin the Sogn-Florence association of Geary County. Areas similar to the Sogn-Florence association in that county are divided into the Clime-Sogn association and the Benfield-Florence association in Riley County.

6. *Benfield-Florence association*

Moderately deep, sloping and moderately steep, silty clay loams and cherty silt loams; on uplands

This association is in the eastern and southern parts of Riley County. The drainageways in the areas are well established and many are in deep valleys. Figure 3 shows the major soils of the association and their normal position on the landscape.

This association makes up about 12 percent of the survey area. It is 38 percent Benfield soils, 25 percent Florence soils, and 11 percent Tully soils. Minor soils make up the remaining 26 percent.

Benfield soils typically are between areas of Florence soils or between Florence and Tully soils. Benfield soils are sloping and moderately steep and are well drained. Their surface layer is silty clay loam about 6 inches thick. The subsoil, about 24 inches thick, is heavy silty clay loam and silty clay. The underlying material is silty clay loam. Shale is at a depth of 35 inches.

Florence soils typically are on the upper rim of the slopes, just above the Benfield soils. Smaller areas, however, are at the lower part of some slopes, just below the Benfield soils. Florence soils are sloping and moderately steep and are well drained. Their surface layer is cherty silt loam and cherty silty clay loam about 10 inches thick. The subsoil is cherty silty clay about 20 inches thick. Limestone bedrock is at a depth of 30 inches.

Tully soils are on foot slopes and are gently sloping

and sloping. These soils are deep and well drained. They have a silty clay loam surface layer about 10 inches thick. The subsoil is heavy silty clay loam surface layer about 10 inches thick. The subsoil is heavy silty clay loam or silty clay that extends to a depth of 51 inches. The substratum is silty clay.

Most of the acreage in minor soils consists of Alluvial land and Ivan, Kennebec, Clime, Sogn, Dwight, and Irwin soils.

Most of this association is used as rangeland. Management is mainly concerned with keeping the mid and tall grasses in excellent condition. Some areas require brush control. The small areas of Tully, Dwight, Irwin, Ivan, and Kennebec soils are suitable for cultivated crops.

Seepage is common from farm ponds that have been constructed where layers of cherty limestone are exposed in the reservoir area. Well water is difficult to locate in the association. The Florence soils are a source of chert rock and gravel.

Parts of this association adjoin the Sogn-Florence association of Geary County. The Sogn-Florence association of that county is similar to the combined Benfield-Florence and Clime-Sogn associations of Riley County.

Descriptions of the Soils

This section describes the soil series and mapping units of Riley County and part of Geary County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure is first to describe the soil series, and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. The description of each mapping unit contains suggestions on how the soil can be managed.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Alluvial land and Stony steep land, for example, are miscellaneous land types that do not belong to a soil series. They are listed, nevertheless, in alphabetic order along with the soil series.

In comparing a mapping unit with a soil series, many will prefer to read the short description in paragraph form. It precedes the technical description that identifies layers by A, B, and C horizons and depth ranges. The technical profile descriptions are mainly for soil scientists and others who want detailed information about soils. Unless otherwise indicated, the colors given in the descriptions are those of dry soil. Some of the terms used to describe the soils are defined in the Glossary at the back of this soil survey.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit, range site, woodland suitability group, and windbreak suitability group in which the mapping unit has been placed. The pages on which each range site, woodland suitability group, and windbreak suitability group

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

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Alluvial land	7,491	2.0	Reading silt loam, 0 to 1 percent slopes	12,018	3.1
Benfield-Florence complex, 5 to 20 percent slopes	32,128	8.2	Reading silt loam, 1 to 3 percent slopes	6,469	1.7
Breaks-Alluvial land complex	13,918	3.6	Sarpy loamy fine sand	2,132	.5
Carr-Sarpy complex	3,384	.9	Smolan silt loam, 1 to 4 percent slopes	4,031	1.0
Chase silty clay loam	4,206	1.1	Smolan silt loam, 4 to 8 percent slopes	2,586	.7
Clime-Sogn complex, 5 to 20 percent slopes	78,424	20.1	Smolan silty clay loam, 4 to 8 percent slopes, eroded	1,954	.5
Dwight-Irwin complex, 1 to 4 percent slopes	17,565	4.5	Stony steep land	17,304	4.4
Dwight-Irwin complex, 1 to 4 percent slopes, eroded	13,743	3.4	Sutphen silty clay	2,525	.6
Elmont silt loam, 3 to 8 percent slopes	787	.2	Tully silty clay loam, 1 to 4 percent slopes	689	.2
Elmont-Clime complex, 5 to 15 percent slopes	1,455	.4	Tully silty clay loam, 1 to 4 percent slopes, eroded	1,213	.3
Eudora silt loam	5,860	1.5	Tully silty clay loam, 4 to 8 percent slopes	7,205	1.8
Geary silt loam, 1 to 4 percent slopes	742	.2	Tully silty clay loam, 4 to 8 percent slopes, eroded	7,427	1.9
Geary silt loam, 4 to 8 percent slopes	2,592	.7	Wymore silty clay loam, 0 to 1 percent slopes	2,536	.6
Haynie very fine sandy loam	5,951	1.5	Wymore silty clay loam, 1 to 4 percent slopes	14,030	3.6
Irwin silty clay loam, 4 to 8 percent slopes	18,224	4.7	Wymore silty clay loam, 1 to 4 percent slopes, eroded	46,084	11.8
Irwin silty clay loam, 4 to 8 percent slopes, eroded	28,760	7.4	Wymore silty clay loam, 4 to 8 percent slopes	1,629	.4
Ivan silty clay loam, 1 to 3 percent slopes	575	.1	Wymore silty clay loam, 4 to 8 percent slopes, eroded	3,070	.8
Ivan and Kennebec silt loams	13,425	3.4	Borrow pits	438	.1
Kahola silt loam	1,020	.3	Quarries	263	(1)
Kenesaw silt loam, 2 to 6 percent slopes	412	.1	Tuttle Creek Dam	58	(1)
Kenesaw silt loam, 6 to 10 percent slopes	393	.1			
Mayberry clay loam, 2 to 6 percent slopes	1,083	.3	Total	390,824	100.0
Mayberry clay loam, 2 to 6 percent slopes, eroded	1,105	.3			
Muir silt loam	3,920	1.0			

[1] Less than 0.1 percent.

are described can be found by referring to the "Guide to Mapping Units" at the back of this survey. The soils not assigned to woodland suitability groups are not suitable as woodland.

Alluvial Land

Alluvial land (0 to 6 percent slopes) (Ad) is in intermittent drainageways and on dissected flood plains of major streams (fig. 7).

The soils are deep, distinctly stratified, and variable in texture, color, and reaction. The surface layer is silt loam, clay loam, or silty clay loam and ranges from gray to dark brown. Reaction is slightly acid to moderately alkaline. The layers below the surface layer range from silt loam to light silty clay and from light gray to dark grayish brown or dark brown. Reaction ranges from neutral to moderately alkaline. In about 10 percent of the areas, the soils have limestone gravel in one or more horizons.

Alluvial land is associated with Ivan, Kennebec, Reading, Tully, Clime, Sogn, Benfield, and Florence soils.

Stream channels and steep escarpments make up about 15 percent of Alluvial land. The channels are about 4 to 20 feet deep and 10 to 80 feet wide.

The land is frequently flooded, but water remains on the surface for only short periods. Permeability of the soils is moderate or moderately slow.

Alluvial land generally is not suited to cultivated crops, because it is frequently flooded and is cut by meandering stream channels. This land is suitable as range, pasture, or woodland, and it provides excellent wildlife habitat. Proper distribution of grazing and control of brush help to maintain range and pasture grasses. Woodland and wildlife areas need protection from fire. (Capability unit VIw-1, Loamy Lowland range site, woodland suitability group 1, windbreak suitability group A)

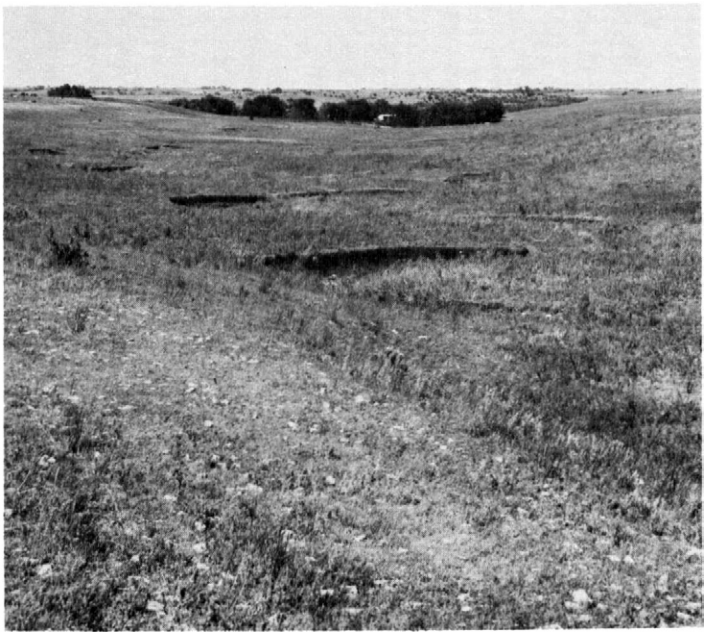

Figure 7.—Alluvial land between areas of the Clime-Sogn complex, 5 to 20 percent slopes.

Benfield Series

The Benfield series consists of moderately deep, sloping and moderately steep soils on uplands. These soils formed in residuum and colluvium that weathered from shale and limestone.

In a representative profile the surface layer is very dark gray silty clay loam about 6 inches thick. The subsoil extends to a depth of 30 inches and consists of four different layers. The upper layer of the subsoil is dark-gray heavy silty clay loam about 6 inches thick. The next layer is dark grayish-brown light silty clay about 5 inches thick. Next is a layer of brown silty clay about 9 inches thick. The lower layer is mixed pale-yellow and grayish-brown heavy silty clay loam about 4 inches thick. The subsoil is very hard when dry and is firm when moist. The substratum is pale-yellow silty clay loam. Partly weathered shale is at a depth of 35 inches.

The Benfield soils are well drained. Surface runoff is medium to rapid, and permeability is slow.

Representative profile of Benfield silty clay loam in an area of Benfield-Florence complex, 5 to 20 percent slopes, 1,530 feet east and 40 feet north of the southwest corner of sec. 27, T. 9 S., R. 7 E., in native grass:

A1—0 to 6 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; moderate, fine, granular structure; hard when dry, friable when moist; common roots; few fragments of chert less than 2 inches in diameter; mildly alkaline; clear, wavy boundary.

B1—6 to 12 inches, dark-gray (10YR 4/1) heavy silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine and very fine, subangular blocky structure; very hard when dry, firm when moist; common roots; common fragments of chert less than 2 inches in diameter; mildly alkaline; clear, wavy boundary.

B21t—12 to 17 inches, dark grayish-brown (10YR 4/2) light silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; very hard when dry, firm when moist; common roots; few fragments of chert less than three-fourths inch in diameter; few concretions of iron and manganese; mildly alkaline; clear, wavy boundary.

B22t—17 to 26 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) when moist; moderate, fine, blocky structure; very hard when dry, firm when moist; few roots; few pockets of worm casts; few fragments of chert less than three-fourths inch in diameter; few concretions of iron and manganese; mildly alkaline; gradual, wavy boundary.

B3ca—26 to 30 inches, pale-yellow (5Y 7/3) and grayish-brown (10YR 5/2) heavy silty clay loam, olive (5Y 5/3) and dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; few roots; few concretions of iron and manganese; few concretions of carbonate in lower part of horizon; calcareous; moderate alkaline; clear, wavy boundary.

Cca—30 to 35 inches, pale-yellow (5Y 7/3) silty clay loam, olive (5Y 5/3) when moist; few, fine, distinct mottles of strong brown (7.5YR 5/6); weak, thin, platy structure and weak, fine, subangular blocky structure; hard when dry, firm when moist; few roots; few concretions of iron and manganese; few concretions of carbonate; calcareous; moderately alkaline; gradual, wavy boundary.

R—35 inches, pale-yellow (5Y 7/3), partly weathered platy shale, olive (5Y 5/3) when moist; few, medium, distinct mottles of strong brown (7.5YR 5/6); few concretions of iron and manganese; calcareous; moderately alkaline.

The A and B horizons range from 20 to 40 inches in combined thickness. Depth to weathered calcareous shale is 22 to 40 inches. The A horizon, when dry, is dark gray, very dark gray, dark grayish brown, or very dark grayish brown. The B2t horizon ranges from brown or dark brown to dark grayish brown or very dark grayish brown. The C horizon ranges from pinkish gray and reddish gray to pale yellow or olive. Some fragments of chert or limestone are in one or more horizons of most profiles, but they make up less than 35 percent of the total volume of any one horizon. Benfield soils range from neutral or mildly alkaline in the A1 and B21t horizons to mildly alkaline or moderately alkaline in the B22t horizon. Depth to free carbonates ranges from 28 to 40 inches.

Benfield soils are mapped in a complex with Florence soils. The Benfield soils formed in parent material that is similar to that of the Tully soils, and they are on landscapes that are similar to those of the Clime soils. Benfield soils are less cherty in the B horizon than Florence soils, are shallower to bedrock than the Tully soils, and are deeper to free carbonate than the Clime soils.

Benfield-Florence complex, 5 to 20 percent slopes (Bf).—This complex consists mainly of Benfield and Florence soils. Most areas of the Florence soils are on the narrow ridgetop or upper part of the slope, but some areas are at the bottom of the slope. The Benfield soils are between the areas of Florence soils (fig. 8).

Benfield silty clay makes up 35 to 55 percent of the complex, and Florence cherty silt loam makes up 20 to 40 percent. Both soils have the profiles described as representative for their respective series.

Included in mapping were areas of Clime silty clay loam that make up about 10 percent of the mapping unit, and areas of Sogn silty clay loam that make up about 5 percent. Also included were a few small areas of Irwin silty clay loam, Dwight silt loam, and Tully silty clay loam.

The soils in this complex take water well and readily release it for plant use. In the Florence soil, however, the available water capacity is very low, and in the Benfield soil it is only moderate. Erosion is a severe hazard in unprotected areas.

Soils of this complex are not suitable for crops, because some areas contain chert and limestone fragments, are moderately steep, or are only moderately deep to bedrock. Most areas are used as native rangeland. In well-managed areas, little bluestem, big bluestem, and indiangrass make up most of the grass cover. The key management practice on range is proper grazing. Brush is a concern where these soils have been overgrazed.

The soils in this complex can be used to grow trees for windbreaks and to develop wildlife habitat. (Both soils, capability unit VIe–2, Loamy Upland range site; Benfield soil, windbreak suitability group C; Florence soil, windbreak suitability group F)

Breaks-Alluvial Land Complex

Breaks-Alluvial land complex (0 to 50 percent slopes) (Bk) is in small, V-shaped, intermittent drainageways (fig. 9). It is associated with all the arable soils on uplands in the survey area. Narrow bottom lands make up 30 to 50 percent of this complex, and the adjoining broken side slopes 50 to 70 percent. The areas are 125 to 400 feet wide and 1,000 to 5,000 feet long. Slope ranges from nearly level in some areas of the bottom lands to steep on some of the side slopes.

Most areas of the soils on side slopes are deep. The parent material is loess, residuum weathered from shale and from limestone, or old alluvium. The surface layer

Figure 8.—Typical area of Benfield-Florence complex, 5 to 20 percent slopes.

Figure 9.—**Typical area of Breaks-Alluvial land complex.**

is generally silt loam or silty clay loam 4 to 12 inches thick. It is medium acid or slightly acid. The subsoil and substratum are silty clay loam or silty clay, and they are slightly acid to moderately alkaline. The side slopes include a few small areas of shallower soils, such as Clime silty clay loam and Sogn silty clay loam. Permeability is slow to moderately slow. Surface runoff is rapid, and the hazard of erosion is severe.

The soils on bottom lands are deep and stratified. They formed in alluvial and colluvial sediments. The surface layer is silt loam, clay loam, or silty clay loam that is slightly acid to moderately alkaline. The lower layers are silt loam to light silty clay, and they are neutral to moderately alkaline. Permeability is moderate to moderately slow. These soils are frequently flooded.

Soils of this complex are not suited to cultivated crops. Most areas are used as range, pasture, or wildlife habitat. Big bluestem, little bluestem, indiangrass, and switchgrass make up most of the native vegetation. Where this complex is used as range or pasture, controlled grazing should be a management practice. In many areas brush control is required. Areas used for wildlife habitat should be protected from burning. (Both parts, capability unit VIe-3; Breaks, Clay Upland range site, windbreak suitability group E; Alluvial land, Loamy Lowland range site, windbreak suitability group A)

Carr Series

The Carr series consists of nearly level soils on flood plains along the major rivers. These soils formed in calcareous alluvium and have a calcareous substratum.

In a representative profile the surface layer is light brownish-gray light fine sandy loam in the upper part and is grayish-brown fine sandy loam in the lower part. The surface layer is about 17 inches thick. The next layer is light brownish-gray fine sandy loam about 11 inches thick. It is soft when dry and very friable when moist. The layers below a depth of 28 inches are light-gray very fine sandy loam.

Carr soils are well drained to moderately well drained. Surface runoff is slow, and permeability is moderate to rapid.

Representative profile of Carr fine sandy loam in an area of Carr-Sarpy complex, 2,100 feet south and 35 feet west of the northeast corner of sec. 35, T. 10 S., R. 7 E., in a cultivated field:

A11—0 to 9 inches, light brownish-gray (10YR 6/2) light fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak granular structure; soft when dry, very friable when moist; few roots; calcareous; moderately alkaline; gradual boundary.

A12—9 to 17 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10 YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few roots; few worm casts; calcareous; moderately alkaline; clear, smooth boundary.

AC—17 to 28 inches, light brownish-gray (10YR 6/2) fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few roots; few worm casts; calcareous; moderately alkaline; gradual, smooth boundary.

C1—28 to 38 inches, light-gray (10YR 7/2) very fine sandy loam, grayish brown (10YR 5/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few roots and pores; few worm casts; calcareous; moderately alkaline; gradual, smooth boundary.

C2—38 to 60 inches, light-gray (10YR 7/2) very fine sandy loam, grayish brown (10YR 5/2) when moist; few, fine, very faint mottles of yellowish brown; massive; soft when dry, friable when moist; few roots; calcareous; moderately alkaline.

The A1 horizon, when dry, is light brownish gray, grayish brown, gray, dark gray, brown, or pale brown. The C horizon is light gray, light brownish gray, pale brown, or very pale brown. The horizons between depths of 10 and 40 inches range from sandy loam to light loam. More than 15 percent of these horizons is fine and coarse sand, and less than 15 percent is clay. Depth to free carbonates is less than 10 inches.

Carr soils are mapped in a complex with Sarpy soils. The Carr soils also are near the Eudora and Haynie soils and are on similar landscapes. Carr soils are finer textured throughout the upper 40 inches of the profile than the Sarpy soils, and they are coarser textured throughout their profile than the Eudora and Haynie soils.

Carr-Sarpy complex (0 to 1 percent slopes) (Ca).—This complex consists mainly of Carr fine sandy loam and Sarpy loamy fine sand on flood plains along the Kansas, Republican, and Big Blue Rivers. The Carr soil is in areas that are slightly concave, and the Sarpy soil is in areas that are slightly convex.

Carr fine sandy loam makes up about 30 percent of the complex, and Sarpy loamy fine sand makes up about 25 percent. About 15 percent consists of soils that are similar to Carr fine sandy loam, except that the surface layer is loamy fine sand; about 15 percent consists of soils that are similar to Sarpy loamy fine sand, except that the surface layer is fine sandy loam.

Included in mapping were areas of Haynie very fine sandy loam that make up about 15 percent of the complex. Also included were small areas of dune land and of small, poorly drained depressions that are shown on the detailed soil map by symbols. Each symbol for dune land and for depressions represents an area less than 5 acres in size.

The Carr soil has moderate to high available water capacity, and the Sarpy soil has low available water capacity. Some areas are subject to flooding during periods of excessive rainfall. In most years, flooding is minor in extent and crop damage is slight. Some flooding, however, causes serious damage to crops where silt and sand deposits are left on the soil. Soil blowing also is a hazard where the surface is not protected by a cover of plants or by crop residues.

Good management of crop residues is needed to control soil blowing. A good cropping system is one that provides a cover crop for the soil throughout the year. Using stubble-mulch tillage and alternating tall-growing crops with short-growing crops are good practices that help to control soil blowing. Cover cropping and adding manure help to maintain fertility and tilth. A sprinkler irrigation system is more effective than a gravity system if these soils are irrigated.

Wheat, grain sorghum, corn, and alfalfa are the most common crops grown on Carr and Sarpy soils. These soils also are suited to certain specialty crops, to tame and native perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Both soils, capability unit IIIw-1, woodland suitability group 4. Windbreak suitability group H; Carr soil, Sandy Lowland range site; Sarpy soil, Sands range site)

Chase Series

The Chase series consists of deep, nearly level soils on terraces along the Kansas and Big Blue Rivers and along the larger creeks. These soils formed in alluvium.

In a representative profile the surface layer is dark-gray silty clay loam about 13 inches thick. The subsoil is dark-gray silty clay in the upper 27 inches and gray silty clay in the lower 10 inches. It is very hard when dry and firm when moist. It extends to a depth of about 50 inches. The substratum is gray silty clay to a depth of 60 inches.

Chase soils are somewhat poorly drained to moderately well drained. Surface runoff and permeability are slow.

Representative profile of Chase silty clay loam, 3,580 feet east and 480 feet south of the northwest corner of sec 31, T. 9 S., R. 8 E., in a cultivated field:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; hard when dry, friable when moist; few roots; few worm casts; medium acid; clear, smooth boundary.

A3—7 to 13 inches, dark-gray (10YR 4/1) heavy silty clay loam, black (10YR 2/1) when moist; moderate, fine, blocky structure; very hard when dry, firm when moist; few roots; slightly acid; clear, smooth boundary.

B21t—13 to 21 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when moist; weak, very fine, blocky structure; very hard when dry, firm when moist; few roots; neutral; clear, smooth boundary.

B22t—21 to 40 inches, dark-gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) when moist; weak, fine and very fine, blocky structure; very hard when dry, firm when moist; few roots; few black concretions of iron and manganese; neutral; gradual, smooth boundary.

B3—40 to 50 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) when moist; weak, fine, blocky structure; very hard when dry, firm when moist; few black concretions of iron and manganese; few carbonate concretions; moderately alkaline; gradual, smooth boundary.

C—50 to 60 inches, gray (10YR 5/1) silty clay, dark gray (10YR 4/1) when moist; weak, medium, blocky structure; very hard when dry, firm when moist; few concretions of iron and manganese; few carbonate concretions, moderately alkaline.

The A and B horizons range from 36 to 60 inches in combined thickness. The A horizon, when dry, is dark gray, very dark gray, dark grayish brown, or very dark grayish brown. The B2t horizons range from gray or grayish brown to very dark gray or very dark grayish brown. The C horizon ranges from light gray or light brownish gray to dark gray or dark grayish brown. Chase soils are medium acid to neutral above a depth of 40 inches, and they are slightly acid to moderately alkaline below a depth of 40 inches. Carbonate concretions occur below a depth of 40 inches in some profiles.

Chase soils are mapped near the Reading soils on large bottom lands of creeks and near the Sutphen soils on bottom lands of rivers. Chase soils are more clayey in the A and B horizons than Reading soils and are less clayey in the A horizon than Sutphen soils.

Chase silty clay loam (0 to 1 percent slopes) (Ch).—This is the only Chase soil mapped in the survey area.

Included in mapping were areas of Reading silt loam that make up about 10 percent of the mapping unit and small areas of Sutphen silty clay. Small slick spots and included areas of soils where silt deposits are 10 to 36 inches thick are shown on the detailed soil map by symbols. Each symbol shown for a slick spot represents an area less than 2 acres in size. Each symbol shown for a silt deposit represents an area less than 6 acres in size.

Chase silty clay loam is fertile and has a high available water capacity. It is rarely flooded, but some crop loss occurs in wet periods in some of the low areas that

are somewhat poorly drained. The main concern of management is the maintenance of fertility and good soil tilth. Good management of crop residues keeps the surface layer in condition to take water readily and to work easily.

Nearly all of this soil is cultivated. The soil is suited to all crops commonly grown in the survey area. Corn and sorghum can be grown continuously if crop residues are returned to the soil. Wheat, grain sorghum, corn, and alfalfa are the main crops grown.

This soil also is suited to tame and native perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit IIw-2, Loamy Lowland range site, woodland suitability group 3, windbreak suitability group A)

Clime Series

The Clime series consists of moderately deep, sloping to moderately steep, calcareous soils on uplands (fig. 10). These soils formed in residuum weathered from calcareous clayey shale.

In a representative profile the surface layer is dark gray in the upper part and grayish brown in the lower part. It is silty clay loam about 12 inches thick. The subsoil is mixed grayish-brown and light brownish-gray heavy silty clay loam. It is about 8 inches thick, and it is hard when dry and firm when moist. The substratum is mixed pinkish-gray and light-gray heavy silty clay loam. Calcareous silty clay shale is at a depth of about 30 inches.

Clime soils are moderately well drained to well drained. They have moderately slow permeability.

Representative profile of Clime silty clay loam in an area of Clime-Sogn complex, 5 to 20 percent slopes, located 2,010 feet south and 1,880 feet east of the northwest corner of sec. 36, T. 9 S., R. 7 E., in native grass:

A11—0 to 8 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; hard when dry, firm when moist; common roots; few worm casts; few fragments of limestone less than one-half inch in diameter; calcareous; moderately alkaline; clear, smooth boundary.

A12—8 to 12 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; hard when dry, firm when moist; common roots; few small fragments of limestone; common worm casts; calcareous; moderately alkaline; clear, smooth boundary.

B2—12 to 20 inches, grayish-brown (10YR 5/2) and light brownish-gray (10YR 6/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) when moist; moderate, fine and very fine, subangular blocky structure; hard when dry, firm when moist; common roots; few worm casts; few fragments of limestone less than one-half inch in diameter; calcareous; moderately alkaline; gradual, smooth boundary.

C—20 to 30 inches, mixed pinkish-gray (7.5YR 6/2) and light-gray (2.5YR 7/2) heavy silty clay loam, average crushed color is grayish brown (10YR 5/2) when moist; moderate, fine and very fine, subangular blocky structure; hard when dry, firm when moist; few roots; few small fragments of shale; calcareous; moderately alkaline; clear, smooth boundary.

Figure 10.—**Profile of Clime silty clay loam. The substratum, indicated by the arrow, contains many shale fragments. The depth to unweathered shale is about 20 inches.**

R—30 inches, light-gray (5Y 7/2), weathered, clayey shale; olive (5Y 5/3) when moist; few fine roots in upper few inches; calcareous; moderately alkaline.

Depth to shale ranges from 20 to 40 inches. When dry, the A1 horizon ranges from gray or grayish brown to very dark gray or very dark grayish brown. The B2 horizon ranges from gray or light brownish gray to dark gray or dark grayish brown. The B2 horizon is heavy silty clay loam or light silty clay. The C horizon has a wide range of colors that are inherited from the parent shale. Colors range from brown to pink at one extreme to olive to pale yellow at the other extreme. The C horizon is silty clay, clay, or heavy silty clay loam. Clime soils are calcareous within 10 inches of the soil surface. They are mildly alkaline or moderately alkaline in the A1 horizon.

Clime soils are mapped in complexes with the Sogn and the Elmont soils. The Clime soils are on landscapes that are similar to those of the Benfield soils. They are deeper to bedrock than the Sogn soils, shallower to bedrock than the Elmont soils, and more alkaline in the A and B horizons than the Benfield soils.

Clime-Sogn complex, 5 to 20 percent slopes (Cs).—This complex consists of Clime and Sogn soils. These

soils are in alternate narrow bands that run along the contour of the slope (fig. 11). The bands of Clime silty clay loam generally are 25 to 300 feet wide, and the bands of Sogn silty clay loam are 10 to 125 feet wide. The Clime soil ranges from 5 to 20 percent in slope, and the Sogn soil from 5 to 8 percent.

Clime silty clay loam makes up about 40 to 60 percent of the complex, and Sogn silty clay loam 20 to 40 percent. These soils have the profiles described as representative for their respective series.

Included in mapping were areas of soils that are similar to Clime silty clay loam, except that they are only 10 to 20 inches deep to shale bedrock. Also included were some areas of Irwin silty clay loam and of limestone outcrops. These included areas make up about 20 percent of the complex.

The soils in this complex take water slowly, and they lose much water by runoff. The available water capacity is low in the Clime soil and is very low in the Sogn soil. These soils are susceptible to water erosion, particularly where the surface is unprotected. The chief concerns of management are the control of erosion and the maintenance and improvement of desirable range grasses.

This complex is well suited to native grass for range. Some areas are suited to native hay for meadows. The native vegetation is dominantly big bluestem, little bluestem, and forbs, such as blacksampson.

The desirable grasses are replaced by weeds and brush where overgrazing has occurred. Proper range management will keep this native rangeland in good condition.

The soils in this complex can be used to grow trees for windbreaks if suitable species are selected. They are suited to development of wildlife habitat. (Both soils, capability unit VIe-1; Clime soil, Limy Upland range site, windbreak suitability group D; Sogn soil, Shallow Limy range site, windbreak suitability group G)

Dwight Series

The Dwight series consists of gently sloping soils on uplands. These soils have a thin surface layer and a dense subsoil. They formed in material derived mostly from weathering shale.

In a representative profile the surface layer is dark-gray silt loam about 4 inches thick. The subsoil extends to a depth of about 43 inches. In the upper part it is dark grayish-brown silty clay that is very hard when dry and very firm when moist. The middle part is dark-brown silty clay that is very hard when dry and firm when moist. The lower part is brown and reddish-brown light silty clay. It is very hard when dry and firm when moist. Soft shale is at a depth of 43 inches and limestone is at a depth of 48 inches.

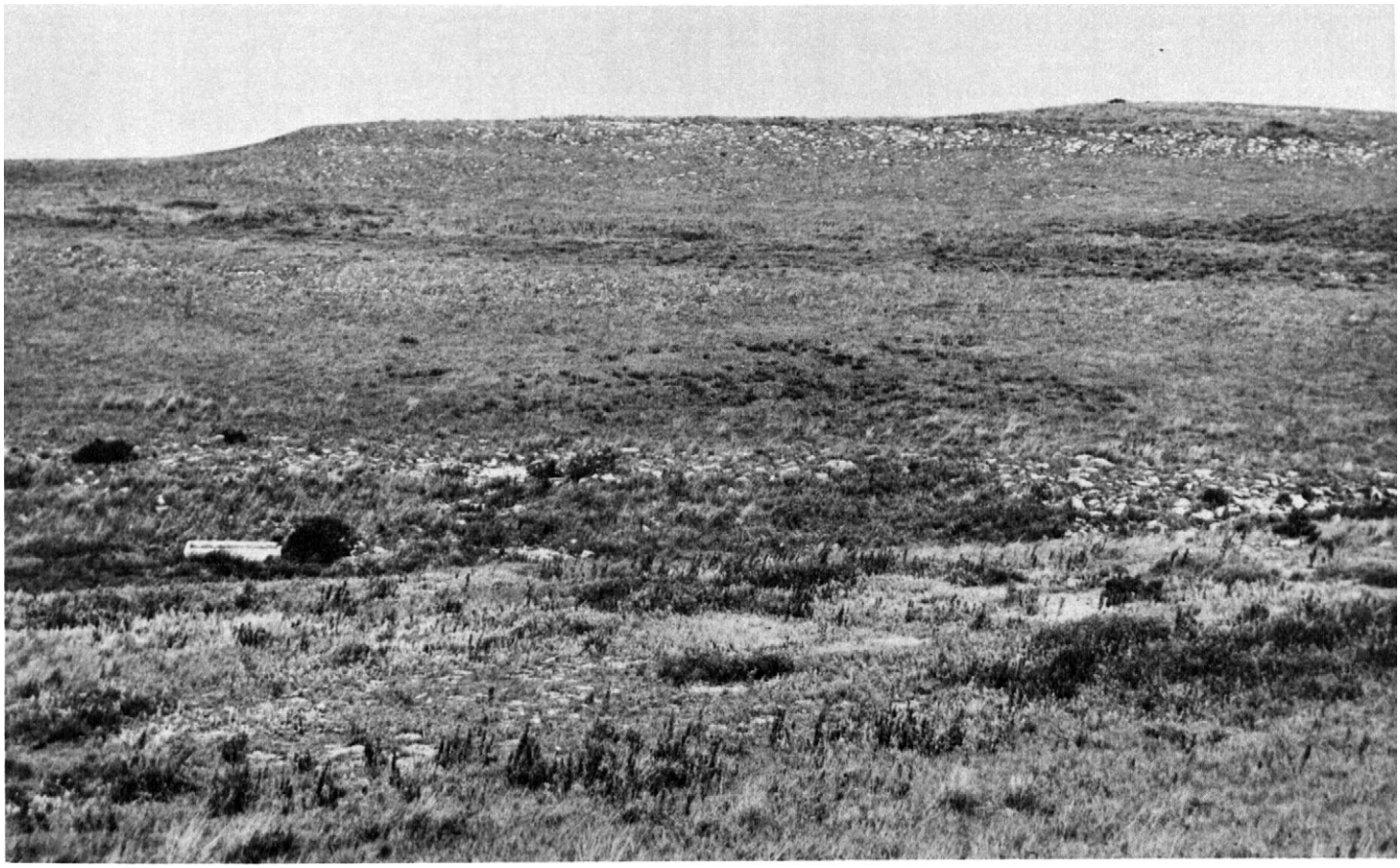

Figure 11.—Typical area of Clime-Sogn complex, 5 to 20 percent slopes. Clime silty clay loam is immediately below the limestone outcrops and Sogn silty clay loam is immediately above the outcrops.

Dwight soils are moderately well drained. They are very slowly permeable.

Representative profile of Dwight silt loam in an area of Dwight-Irwin complex, 1 to 4 percent slopes, located 2,170 feet east and 660 feet north of the southwest corner of sec. 13, T. 8 S., R. 6 E., in native grass:

A1—0 to 4 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; hard when dry, friable when moist; common roots; slightly acid; abrupt, smooth boundary.

B21t—4 to 9 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, medium, columnar structure; light-gray coatings are on tops of columns; very hard when dry, very firm when moist; common roots along ped faces; neutral; clear, smooth boundary.

B22t—9 to 17 inches, dark-brown (10YR 4/3) silty clay, dark brown (10YR 3/3) when moist; moderate, medium, blocky strucure; very hard when dry, firm when moist; few roots; few concretions of lime in lower part of horizon; moderately alkaline; clear, smooth boundary.

B31—17 to 27 inches, brown (7.5YR 5/4) light silty clay, dark brown (7.5YR 4/4) when moist; common, fine, faint, brown (10YR 5/3) mottles; weak, medium, blocky structure; very hard when dry, firm when moist; few concretions of iron and manganese; few soft concretions of carbonate; moderately alkaline; gradual boundary.

B32—27 to 43 inches, mottled reddish-brown (5YR 5/4) and brown (10YR 5/3) light silty clay, reddish brown (5YR 4/4) and dark brown (10YR 4/3) when moist; weak, fine, blocky structure; very hard when dry, firm when moist; few small fragments of chert; few fragments of weathered shale in lower part of horizon; few concretions of iron and manganese; moderately alkaline; gradual, smooth boundary.

R—43 to 48 inches, pale-yellow (5Y 8/3), soft, weathered shale, light yellowish brown (2.5Y 6/4) when moist; calcareous; moderately alkaline; abrupt boundary.

IIR—48 inches+, limestone.

The A horizon is silt loam 2 to 7 inches thick. The B2t horizon is silty clay. The transition from the A horizon to the B2t horizon is within a thickness of 1 inch. The A and B horizons range from about 30 to 55 inches in combined thickness. Depth to shale or limestone is 40 to 60 inches. The A horizon, when dry, ranges from gray or dark gray to grayish brown or dark grayish brown. The B21t horizon is dark grayish brown or very dark grayish brown. The B22t and B31 horizons range from dark brown or very dark grayish brown to light brown. In places a C horizon underlies the B3 horizon. The C horizon ranges from 5YR to 10YR in hue. Carbonate concretions are at a depth of more than 14 inches in some places. Dwight soils range from medium acid to neutral in the A horizon, slightly acid to moderately alkaline in the B2t horizon, and neutral to moderately alkaline in the B3 horizon.

Dwight soils are mapped in complexes with Irwin soils. Dwight soils are on landscapes that are similar to those of the Mayberry and Wymore soils. Dwight soils have a thinner A horizon and a more abrupt transition to the B2t horizon than the Irwin, Mayberry, and Wymore soils. They also have a more clayey C horizon than the Wymore soils, and they lack the glacial pebbles of the Mayberry soils.

Dwight-Irwin complex, 1 to 4 percent slopes (Dr).—This complex consists of Dwight and Irwin soils on ridgetops. Dwight silt loam makes up about 30 to 50 percent of the complex, and Irwin silty clay loam 20 to 40 percent.

The Dwight soil has the profile described as representative for the Dwight series. The Irwin soil has a profile that is similar to the one described as representative for the Irwin series.

Included in mapping were small areas of Wymore silty clay loam and minor areas of Clime silty clay loam. These areas of included soils have slopes of 3 to 6 percent. Rock outcrops and small severely eroded areas are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area less than 1 acre in size. Each symbol shown for a severely eroded area represents an area less than 5 acres in size.

The available water capacity is moderate in the Dwight soil and is high in the Irwin soil, but the subsoil of both soils takes in and releases water very slowly. The fine-textured subsoil restricts the growth of roots. Management is needed to maintain good soil structure and fertility and to increase the intake of water. Water erosion is the main concern of management.

Terracing and contour farming help control erosion on these soils. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce water erosion and soil blowing, to increase the intake of water, and to keep the surface layer in good tilth.

Most areas of this complex are used as native grass rangeland. Some areas are in native hay meadow (fig. 12), and some are cultivated. Wheat and grain sorghum are the main cultivated crops, and some alfalfa is grown.

These soils also are suited to trees for windbreaks and to the development of wildlife habitat. (Both soils, capability unit IIIe-3, windbreak suitability group E; Dwight soil, Claypan range site; Irwin soil, Clay Upland range site)

Dwight-Irwin complex, 1 to 4 percent slopes, eroded (Dw).—This complex consists of Dwight and Irwin soils on ridgetops. Dwight soils make up about 30 to 50 percent of the complex, and Irwin soils 20 to 40 percent.

The Dwight and Irwin soils have profiles that are similar to those described as representative for their respective series, except that water erosion has removed much of the original surface layer. In most places, tillage has mixed material from the subsoil with the remaining part of the original surface layer. The present surface layer is mostly silty clay loam, but it ranges to silty clay.

Included in mapping were small areas of Wymore silty clay loam, eroded. Also included were minor areas of Clime silty clay loam. Rock outcrops and small slick spots are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area less than 1 acre in size. Each symbol shown for a slick spot represents an area less than 2 acres in size.

The available water capacity is moderate in the Dwight soils and is high in the Irwin soils. The subsoil in the soils of both series is dense silty clay. It takes in and releases water very slowly, and it restricts the growth of roots. These soils are hard to till, and surface crusting commonly hinders the emergence of seedlings. Surface runoff is medium to rapid, and erosion is a hazard.

Terracing and contour farming help to control erosion. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to improve the tilth of the surface layer.

Some areas of this complex are cultivated. Wheat and grain sorghum are the main crops. Some areas are seeded to bromegrass, and some have been reseeded to native grasses.

Figure 12.—**Baled native grass on Dwight-Irwin complex, 1 to 4 percent slopes, and Irwin silty clay loam, 4 to 8 percent slopes.**

These soils also are suited to native and tame grasses, trees for windbreaks, and development of wildlife habitat. (Both soils, capability unit IIIe–4, Claypan range site, windbreak suitability group E)

Elmont Series

The Elmont series consists of deep, sloping to moderately steep soils on uplands. These soils formed in material weathered from noncalcareous micaceous shale.

In a representative profile the surface layer is dark-gray silt loam about 10 inches thick. The subsoil extends to a depth of about 33 inches. The upper part of the subsoil is dark-brown light silty clay loam that is slightly hard when dry and friable when moist. In the middle part, the subsoil is dark-brown silty clay loam that is hard when dry and firm when moist. The lower part is brown light silty clay loam. It is hard when dry and friable when moist. The substratum is brown light clay loam. Shale is at a depth of about 44 inches.

Elmont soils are well drained. They have moderately slow permeability.

Representative profile of Elmont silt loam in an area of Elmont-Clime complex, 5 to 15 percent slopes, located 1,940 feet east and 1,500 feet north of the southwest corner of sec. 30, T. 10 S., R. 9 E., in native grass:

A1—0 to 10 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; common roots; few worm casts; slightly acid; clear, smooth boundary.

B1—10 to 18 inches, dark-brown (10YR 4/3) light silty clay loam, dark brown (10YR 3/3) when moist; moderate, very fine, subangular blocky structure; slightly hard when dry, friable when moist; few roots; few worm casts; few hard fragments of sandy shale; medium acid; clear, smooth boundary.

B2t—18 to 28 inches, dark-brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/4) when moist; moderate, fine and very fine, subangular blocky structure; hard when dry, firm when moist; few roots; few worm casts; slightly acid; clear, smooth boundary.

B3—28 to 33 inches, brown (7.5YR 5/4) light silty clay loam, dark brown (7.5YR 4/4) when moist; weak, fine, subangular blocky structure; hard when dry, friable when moist; few roots; few soft fragments of sandy shale; few concretions of fine iron and manganese; slightly acid; clear, smooth boundary.

C—33 to 44 inches, brown (7.5YR 5/4) light clay loam, brown (7.5Y 4/4) when moist; weak, fine, subangular blocky structure; slightly hard when dry, friable when moist; few roots; contains some light yellowish-brown (10YR 6/4) weathered shale that is in weak fine plates and is very fine sandy loam in texture; few stains of reddish-brown iron and manganese; slightly acid; clear, smooth boundary.

R—44 inches, pale-brown (10YR 6/3) micaceous shale, dark brown (10YR 4/3) when moist; mildly alkaline.

The A and B horizons range from 25 to 50 inches in combined thickness. Depth to shale ranges from 40 to 60 inches. When dry, the A horizon ranges from gray and very dark gray to brown and dark brown. The B2t horizon is brown or dark brown. The B3 and C horizons range from brown or pale brown to light olive brown or light yellowish brown. The B2t horizon is silty clay loam that is less than 35 percent clay. The C horizon ranges from clay loam or silty clay loam to light silty clay. The A and B2t horizons are medium acid or slightly acid, and the B3 and C horizons are slightly acid or neutral.

In some places the Elmont soils are mapped in a complex with Clime soils. The Elmont soils are on landscapes that are similar to those of the Irwin soils. They are deeper to bedrock and less alkaline in the A and B horizons than the Clime soils, and they are less clayey throughout the profile than the Irwin soils.

Elmont silt loam, 3 to 8 percent slopes (Em).—This soil has a profile that is similar to the one described as representative for the Elmont series.

Included in mapping were areas of sloping soils that are similar to Elmont silt loam, except that they are 30 to 40 inches deep to shale. These soils make up about 25 percent of the mapping unit. Also included were small areas of Irwin silty clay loam. Rock outcrops are shown on the detailed soil map by a symbol. Each symbol represents an area less than 1 acre in size.

This soil takes water readily if the surface is in good condition. The available water capacity is only moderate, but stored water is readily released for plant use. Surface runoff is medium, and the hazard of erosion is moderate. The major concerns of management are the control of erosion and the maintenance of fertility and good soil tilth.

Terracing and contour farming reduce water erosion in cultivated areas. Good management of crop residues helps to keep the surface layer in condition to take water readily and to work easily.

Wheat and grain sorghum are the main crops grown on this soil. Growth of some crops, such as corn and alfalfa, commonly is reduced in dry periods because the available water capacity is limited.

Most areas are used as native range. The soil also is suited to tame perennial grasses, trees for windbreaks, and development of wildlife habitat. (Capability unit IIIe–5, Loamy Upland range site, Windbreak suitability group C)

Elmont-Clime complex, 5 to 15 percent slopes (En).—This complex consists of Elmont and Clime soils on uplands. These soils generally are in alternate bands that run along the contour of the slope.

Elmont silt loam makes up 25 to 45 percent of the complex, and Clime silty clay loam 20 to 40 percent. About 20 percent of the complex consists of soils that are similar to Elmont silt loam, except that the upper 10 to 20 inches of the profile is 5 to 30 percent limestone and chert fragments.

Elmont silt loam has the profile described as representative for the Elmont series. Clime silty clay loam has a profile that is similar to the one described as representative for the Clime series.

Included in mapping were areas of an Irwin silty clay loam that make up about 10 percent of the mapping unit. Also included were small areas of Sogn silty clay loam.

The soils in this complex take water well, but the available water capacity is low in the Clime soil and is only moderate in the Elmont soil. Surface runoff is medium to rapid, and the hazard of erosion is severe in unprotected areas.

Because some areas of the soils are moderately steep and stony, this complex is not suitable as cropland. Most areas are used as native rangeland. In well-managed areas, big bluestem, little bluestem, and indiangrass make up most of the grass cover. The key management practice on range is proper grazing. Brush is a problem where overgrazing has occurred.

The soils in this complex also can be used to grow trees for windbreaks and to develop wildlife habitat. (Both soils, capability unit VIe–4; Elmont soil, Loamy Upland range site, windbreak suitability group C; Clime soil, Limy Upland range site, windbreak suitability group D)

Eudora Series

The Eudora series consists of deep, nearly level soils that formed in coarse silty alluvium on high flood plains or low terraces along the rivers.

In a representative profile the surface layer is grayish-brown silt loam about 10 inches thick. The next layer is mixed grayish-brown and light brownish-gray silt loam about 8 inches thick. It is soft when dry and very friable when moist. Very pale brown very fine sandy loam is at a depth of 18 to 36 inches. It is soft when dry and very friable when moist. Very pale brown silt loam that includes a few thin strata of dark-gray silty clay loam is at a depth of 36 to 56 inches. Grayish-brown silt loam is at a depth of 56 to 62 inches.

Eudora soils are well drained. They are moderately permeable.

Representative profile of Eudora silt loam, located 2,590 feet west and 2,110 feet north of the southeast corner of sec. 35, T. 10 S., R. 7 E., in a cultivated field:

A1—0 to 10 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few worm casts; slightly acid; clear, smooth boundary.

AC—10 to 18 inches, grayish-brown (10YR 5/2) and light brownish-gray (10YR 6/2) silt loam, very dark grayish brown (10YR 3/2) and grayish brown (10YR 5/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; slightly acid; gradual, smooth boundary.

C1—18 to 36 inches, very pale brown (10YR 7/3) very fine sandy loam, grayish brown (10YR 5/2) when moist; massive; soft when dry, very friable when moist; neutral; clear, smooth boundary.

C2—36 to 56 inches, very pale brown (10YR 7/3) silt loam, grayish brown (10YR 5/2) when moist; a few thin strata of dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; massive; soft when dry, very friable when moist; the silty clay loam strata are hard when dry, firm when moist; calcareous; moderately alkaline; gradual, smooth boundary.

C3—56 to 62 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of dark yellowish brown (10YR 4/4); massive; slightly hard when dry, friable when moist; few carbonate threads; calcareous; moderately alkaline.

The A and AC horizons, when dry, range from very dark gray or very dark grayish brown to gray or grayish brown. The C horizons are light brownish gray, pale brown, very pale brown, or light gray. The layers between depths of 10 and 40 inches are coarse silt loam or very fine sandy loam. Eudora soils are slightly acid or neutral in the A1 horizon and are neutral to moderately alkaline in the C horizons. Depth to free carbonates ranges from 20 to 48 inches.

Eudora soils are mapped near the Carr, Haynie, Muir, and Kahola soils on similar landscapes. Eudora soils have a finer textured profile than the Carr soils. They are deeper to free carbonates than the Haynie soils, are coarser textured above a depth of 40 inches than the Muir soils, and are coarser textured and less alkaline above a depth of 40 inches than the Kahola soils.

Eudora silt loam (0 to 1 percent slopes) (Eu).—This is the only Eudora soil mapped in the survey area.

Included in mapping were small areas of Muir silt loam and Haynie very fine sandy loam. Small included areas of poorly drained soils in depressions are shown on the detailed soil map by a symbol. Each symbol represents an area smaller than 5 acres in size.

Eudora silt loam is easily tilled. It takes in water well and has high available water capacity. It readily releases water for plant use. Maintenance of fertility and tilth is the main concern of management.

This soil is suited to all crops commonly grown in the survey area. Wheat, grain sorghum, corn, alfalfa, and soybeans are the main crops. Any crop that produces sufficient growth can be grown continuously if the residues are returned to the soil and if weeds and insects are controlled. Crop residues returned to the soil keep the surface layer in condition to take water readily and to till easily.

Eudora silt loam is well suited to tame and native perennial grasses, to trees for woodland production and for windbreaks, and to the development of wildlife habitat. (Capability unit I–1, Loamy Lowland range site, woodland suitability group 3, windbreak suitability group A)

Florence Series

The Florence series consists of moderately deep, sloping and moderately steep soils on uplands. These soils are underlain by limestone bedrock (fig. 13). They formed in residuum weathered from cherty limestone.

In a representative profile the surface layer is very dark cherty silt loam and cherty silty clay loam about 10 inches thick. The subsoil extends to a depth of 30 inches. It is very dark gray cherty silty clay in the upper part; dark reddish-brown cherty clay in the middle part; and brown cherty silty clay in the lower part. About 70 to 80 percent of the subsoil consists of chert fragments. The soil material between the fragments is very hard or extremely hard when dry and firm or very firm when moist. The subsoil is directly underlain by limestone bedrock.

Figure 13.—**Profile of Florence cherty silt loam. The depth to consolidated limestone is 30 inches.**

The Florence soils are well drained. Surface runoff is medium to rapid, and permeability is moderately slow.

In this county Florence soils are mapped only in a complex with Benfield soils. A description of the mapping unit is given under the Benfield series.

Representative profile of Florence cherty silt loam in an area of Benfield-Florence complex, 5 to 20 percent slopes, located 1,440 feet east and 1,500 feet south of northwest corner of sec. 35, T. 9 S., R. 7 E., in native grass:

A1—0 to 5 inches, very dark gray (10 YR 3/1) cherty silt loam, black (10YR 2/1) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; many roots; about 20 percent of horizon is angular fragments of chert less than 1½ inches long; neutral; clear, smooth boundary.

A3—5 to 10 inches, very dark gray (10YR 3/1) cherty heavy silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; hard when dry, friable when moist; many roots; about 70 percent of horizon is angular fragments of chert less than 2 inches long; few worm casts; neutral; clear, irregular boundary.

B1—10 to 14 inches, very dark gray (5YR 3/1) cherty silty clay, dark brown (7.5YR 4/2) when crushed, dark reddish brown (5YR 2/2) when moist; dark brown (7.5YR 3/2) when crushed and moist; moderate, fine and medium, granular structure; very hard when dry, firm when moist; many roots; about 80 percent of horizon is angular fragments of chert about 3 inches long; neutral; clear, irregular boundary.

B2t—14 to 25 inches, dark reddish-brown (5YR 3/4) coarse cherty clay, dark reddish brown (5YR 3/4) when moist; some ped surfaces that are adjacent to chert surfaces are dark reddish brown (5YR 3/3) when dry and moist; moderate, fine and medium, blocky structure; extremely hard when dry, very firm when moist; few roots; about 80 percent of horizon is coarse chert; neutral; clear, irregular boundary.

B3—25 to 30 inches, brown (7.5YR 5/4) cherty silty clay, dark brown (7.5YR 4/4) when moist; moderate, fine, subangular blocky and granular structure; very hard when dry, firm when moist; about 70 percent of horizon is fragments of chert and limestone; neutral; clear, irregular boundary.

R–30 inches, limestone that has a few fractures, less than 8 inches deep, filled with soil material that is similar to that of the overlying horizon.

The A horizon, when dry, is dark gray, very dark gray, dark grayish brown, or very dark grayish brown. The B2t and B3 horizons are brown, dark brown, dark reddish brown, and reddish gray. In most places the A horizon is between 20 and 50 percent chert fragments, but in places it is nearly chert free. The B2t and B3 horizons are 35 to 85 percent chert fragments. The fine earth fraction of the B2t horizon is 50 to 80 percent clay. The underlying bedrock is cherty limestone or limestone and is at a depth of 25 to 40 inches. The A and B2t horizons are slightly acid to neutral, and the B3 horizon is slightly acid to mildly alkaline. Free carbonates, if present, are at a depth below 30 inches.

The depth to consolidated limestone in these soils is a little less than in the range defined for the series, but this difference does not alter their usefulness and behavior.

Florence soils are mapped in a complex with Benfield soils. The Florence soils are on landscapes that are similar to those of the Sogn soils. Florence soils are more cherty in the B horizon than the Benfield soils, and they have more chert in the profile and are deeper to limestone bedrock than the Sogn soils.

Geary Series

The Geary series consists of deep, gently sloping and sloping soils on uplands. These soils formed in reddish loess.

In a representative profile the surface layer is dark grayish-brown silt loam about 8 inches thick. The upper part of the subsoil is dark grayish-brown silty clay loam layer about 5 inches thick. The rest of the subsoil is brown silty clay loam. It is hard when dry and firm when moist, and it extends to a depth of 42 inches. The substratum is brown light silty clay loam.

Geary soils are well drained. They have moderate permeability.

Representative profile of Geary silt loam, 1 to 4 percent slopes, located 760 feet west of the southeast corner of sec. 23, T. 10 S., R. 7 E., in native grass:

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; common roots; slightly acid; clear, smooth boundary.

B1—8 to 13 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, very fine, subangular blocky structure; hard when dry, friable when moist; common roots; few worm casts; slightly acid; clear, smooth boundary.

R21t—13 to 21 inches, brown (7.5YR 5/4) silty clay loam, dark brown (10YR 4/3) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; common roots; few worm casts; few fine concretions of iron and manganese; slightly acid; gradual, smooth boundary.

B22t—21 to 29 inches, brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/3) when moist; moderate, fine, subangular blocky structure; hard when dry, firm when moist; few roots; few fine concretions of iron and manganese; slightly acid; gradual, smooth boundary.

B3—29 to 42 inches, brown (7.5YR 5/4) light silty clay loam, brown (7.5YR 4/4) when moist; weak, medium, subangular blocky structure; hard when dry, firm when moist; few roots and pores; neutral; gradual, smooth boundary.

C—42 to 60 inches, brown (7.5YR 5/4) light silty clay loam, brown (7.5YR 4/4) when moist; weak, coarse, prismatic structure; hard when dry, friable when moist; few roots and pores; few fine concretions of iron and manganese; neutral.

The A and B horizons range from 30 to 50 inches in combined thickness. When dry, the A1 horizon is grayish brown, dark grayish brown, brown, or dark brown. The B2t horizon is brown or reddish brown, and it is light or medium silty clay loam. Geary soils are medium acid to slightly acid in the A and B1 horizons, slightly acid to neutral in the B2 and B3 horizons, and slightly acid to mildly alkaline in the C horizon.

Geary soils are mapped near the Kenesaw and Smolan soils on similar landscapes. Geary soils have a finer textured B horizon than the Kenesaw soils and a coarser textured B horizon than the Smolan soils.

Geary silt loam, 1 to 4 percent slopes (Ga).—Most of this soil is on moderately broad ridgetops. This soil has the profile described as representative for the Geary series.

Included in mapping were small areas of Smolan silt loam.

This Geary soil is easy to till. It takes water easily, and it has a high available water capacity. Crops withstand dry periods on this soil better than on most other soils on uplands in the survey area, because this soil releases water more easily. Surface runoff is medium. Management is needed to control water erosion and to maintain good tilth and fertility.

Terracing and contour farming help control erosion in cultivated areas of this soil. Good management of crop residues helps prevent erosion and keep the surface layer in condition to take water readily and work easily.

Most areas of this soil are used for native grass. This soil is suited to wheat, grain sorghum, corn, alfalfa, and soybeans. It also is suited to trees for windbreaks and to the development of wildlife habitat. (Capability unit IIe–3, Loamy Upland range site, windbreak suitability group C)

Geary silt loam, 4 to 8 percent slopes (Ge).—Most of this soil is on uplands that are below areas of Geary silt loam, 1 to 4 percent slopes.

Included in mapping were small areas of Kenesaw silt loam and small areas of Smolan silt loam. Small areas of severely eroded soils and small areas of sandy soils are shown on the detailed soil map by symbols. Each symbol shown for an area of severely eroded soils represents an area less than 5 acres in size. Each symbol shown for a sandy soil represents an area less than 3 acres in size. The areas of sandy soils consist of materials that are sandy loam or coarser and are at least 20 inches deep.

This Geary soil works easily, and it takes water readily if the surface layer is in good condition. It has a high available water capacity. The water is readily released for plant use. Surface runoff is medium. The major concerns of management are the control of erosion and the maintenance of good tilth and fertility.

Terracing and contour farming help control erosion. Good management of crop residues also helps to control erosion and to keep the surface layer in good condition.

Most areas of this soil are used for native grass. Some areas are cultivated. The soil is well suited to wheat, grain sorghum, corn, alfalfa, and soybeans. It also is suited to trees for windbreaks and to the development of wildlife habitat. (Capability unit IIIe–5, Loamy Upland range site, windbreak suitability group C)

Haynie Series

The Haynie series consists of deep, nearly level, calcareous soils on flood plains along the rivers. These soils formed in calcareous alluvium.

In a representative profile the surface layer is light brownish-gray very fine sandy loam about 10 inches thick. Light brownish-gray coarse silt loam is at a depth of 10 to 20 inches. Gray very fine sandy loam is at a depth of 20 to 30 inches, and light-gray very fine sandy loam is at a depth of 30 to 41 inches. All of these layers are soft when dry and are very friable when moist. Grayish-brown silty clay loam is at a depth of 41 to 47 inches. It is hard when dry and is firm when moist. Light brownish-gray light silty clay loam is at a depth of 47 to 60 inches.

The Haynie soils are well drained to moderately well drained. They have moderate permeability.

Representative profile of Haynie very fine sandy loam,

3,860 feet east and 2,390 feet north of the southwest corner of sec. 19, T. 10 S., R. 8 E., in a cultivated field:

Ap—0 to 10 inches, light brownish-gray (10YR 6/2) very fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak granular structure; soft when dry, very friable when moist; few worm casts; calcareous; moderately alkaline; clear, smooth boundary.

C—10 to 20 inches, light brownish-gray (10YR 6/2) coarse silt loam, dark grayish brown (10YR 4/2) when moist; few, fine, distinct mottles of strong brown (7.5YR 5/6) weak, medium, granular structure; soft when dry, very friable when moist; few worm casts; calcareous; moderately alkaline; clear, smooth boundary.

A1b—20 to 30 inches, gray (10YR 5/1) very fine sandy loam, very dark grayish brown (10YR 3/2) when moist; massive; soft when dry, very friable when moist; few worm casts; calcareous; moderately alkaline; gradual boundary.

ACb—30 to 41 inches, light-gray (10YR 7/2) very fine sandy loam, grayish brown (10YR 5/2) when moist; weak, fine, granular structure; soft when dry, very friable when moist; few worm casts; calcareous; moderately alkaline; clear boundary.

IIC1b—41 to 47 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate; fine, granular structure; hard when dry, firm when moist; calcareous; moderately alkaline; gradual boundary.

IIC2b—47 to 60 inches, light brownish-gray (10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; hard when dry, friable when moist; few threads of carbonate; calcareous; moderately alkaline.

When dry, the A horizon ranges from gray to brown or pale brown. The C horizon ranges from brown or grayish brown to light gray or very pale brown. The 10- to 40-inch layer is mostly coarse silt loam or very fine sandy loam, but it includes thin strata of somewhat more sandy or clayey material in some places. Buried horizons, which are darker and grayer than the surface layer, are below a depth of 20 inches in some profiles. Depth to free carbonates is less than 10 inches.

Haynie soils are mapped near the Carr, Eudora, and Kahola soils. Haynie soils have a finer textured profile than the Carr soils. They are more alkaline above a depth of 40 inches than the Eudora soils. They have a coarser textured profile than the Kahola soils.

Haynie very fine sandy loam (0 to 1 percent slopes) (Ha).—This is the only Haynie soil mapped in the survey area.

Included in mapping were small areas of Eudora silt loam and Carr fine sandy loam. Also included were small, poorly drained depressions that are shown on the detailed soil map by symbols. Each symbol represents an area smaller than 5 acres in size.

This soil is easily tilled. It takes in water well and releases it readily for plant use. It has high available water capacity and is subject to some flooding. Maintenance of fertility and good tilth is the main concern of management.

Haynie very fine sandy loam is suited to all crops commonly grown in the survey area. Wheat, grain sorghum, corn, alfalfa, and soybeans are the main crops. Any crop that produces sufficient vegetative growth can be grown continuously if the residues are returned to the soil and if weeds and insects are controlled. Crop residues returned to the soil keep the surface layer in condition to take water readily and to be tilled easily.

This soil also is well suited to tame and native perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit I-1, Loamy Lowland range site, woodland suitability group 3, windbreak suitability group A)

Irwin Series

The Irwin series consists of deep, gently sloping and sloping soils on upland ridgetops and side slopes. In most places these soils formed in clayey sediments derived mainly from weathered clay shales.

In a representative profile the surface layer is dark-gray and dark grayish-brown silty clay loam about 11 inches thick. The subsoil begins at a depth of 11 inches and extends to a depth of about 50 inches. It is grayish-brown silty clay in the upper part and brown silty clay in the lower part. The subsoil is very hard when dry and is very firm when moist. The substratum is reddish-brown silty clay. Limestone is at a depth of 55 inches.

The Irwin soils are well drained to moderately well drained. They have very slow permeability.

Representative profile of Irwin silty clay loam, 4 to 8 percent slopes, 1,420 feet south and 385 feet west of the northeast corner of sec. 25, T. 8 S., R. 6 E., in native grass:

A1—0 to 6 inches, dark-gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) when moist; weak, very fine, subangular blocky structure and weak, fine, granular structure; hard when dry, friable when moist; common roots; medium acid; clear smooth boundary.

A3—6 to 11 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and very fine, subangular blocky structure; very hard when dry, firm when moist; common roots; slightly acid; clear, smooth boundary.

B21t—11 to 26 inches, grayish-brown (10YR 5/2) silty clay, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of yellowish red (5YR 5/6); moderate, medium, blocky structure; very hard when dry, very firm when moist; common roots; few fine concretions of iron and manganese; slightly acid; gradual, smooth boundary.

B22t—26 to 35 inches, brown (7.5YR 5/2) silty clay, dark brown (7.5YR 4/4) when moist; common, fine, faint mottles of yellowish red (5YR 5/6); weak, medium, blocky structure; very hard when dry, very firm when moist; few roots; few concretions of iron and manganese; neutral; clear, smooth boundary.

B3—35 to 50 inches, brown (7.5YR 5/4) silty clay, dark brown (7.5YR 4/4) when moist; few, fine, faint mottles of yellowish red (5YR 5/6); weak, medium, blocky structure; very hard when dry, firm when moist; few fine when moist; common roots; medium acid; clear, smooth boundary.

C—50 to 55 inches, reddish-brown (5YR 4/3) silty clay, reddish brown (5YR 4/3) when moist; common, fine and medium, distinct mottles of brownish yellow (10YR 6/6) and gray (10YR 5/1); massive; very hard when dry, very firm when moist; few concretions of carbonate or of soft weathered limestone; mildly alkaline; clear, wavy boundary.

R—55 inches, limestone.

The solum ranges from about 30 to 60 inches in thickness. Shale or hard limestone bedrock is at a depth of more than 40 inches. The A1 and A3 horizons range from 7 to 14 inches in combined thickness. The A horizon, when dry, ranges from gray or dark gray to brown. The Bt horizons range from dark grayish brown to light brownish gray to yellowish brown. The C horizon ranges from 5YR to 2.5Y in hue. Calcareous concretions are below a depth of 24

inches in some places. The Irwin soils range from medium acid to neutral in the A horizon and the B21t horizon and from slightly acid to mildly alkaline in the B22t horizon.

In Dwight-Irwin complex, 1 to 4 percent slopes, eroded, and in Irwin silty clay loam, 4 to 8 percent slopes, eroded, most areas of the Irwin soils have light brownish-gray or yellowish-brown layers at a depth of less than 20 inches. This depth is less than is within the range defined for the series, but the difference does not alter the usefulness or behavior of the soils.

Some Irwin soils are mapped in complexes with Dwight soils. Irwin soils are on landscapes that are similar to those of the Wymore, Elmont, and Mayberry soils. They have a profile that is similar to that of the Tully soils, but they are not so deep to a silty clay B2t horizon as the Tully soils. Irwin soils have a thicker A horizon and have a less abrupt transition to the B2t horizon than the Dwight soils. They have a C horizon that is more clayey than the Wymore soils, and they have B and C horizons that are more clayey than the Elmont soils. They lack the glacial pebbles that are in the Mayberry soils.

Irwin silty clay loam, 4 to 8 percent slopes (Ic).—This soil is on uplands. It has the profile described as representative for the Irwin series.

Included in mapping were some areas of Dwight silt loam that make up about 15 percent of the mapping unit. Also included were small areas of Wymore silty clay loam, Clime silty clay loam, and Tully silty clay loam. Rock outcrops and small severely eroded areas are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area less than 1 acre in size. Each severely eroded symbol represents an area less than 5 acres in size.

This soil has high available water capacity, but the subsoil takes in water slowly and releases it slowly for plant use. This soil loses much water as runoff, especially in areas where protective cover is sparse or where water has not been held in place. The hazard of water erosion is severe.

Terracing and contour farming help to control erosion in cultivated areas of this soil. Good management of crop residues helps reduce erosion and increase the intake of water. It also helps to maintain the good tilth of the surface layer. Deep-rooted legumes improve water intake.

Most areas of this soil are used as part of native grass range. Some areas are in native hay meadows (see fig. 12, p. 16), and some areas are cultivated. Wheat and grain sorghum are the main cultivated crops.

This soil also is suited to trees for windbreaks and to development as wildlife habitat. (Capability unit IIIe–6, Clay Upland range site, windbreak suitability group C)

Irwin silty clay loam, 4 to 8 percent slopes, eroded (Id).—This soil is on uplands. It has a profile that is similar to the one described as representative for the series, except that water erosion has removed much of the original surface layer. Tillage has mixed subsoil material with the remaining part of the original surface layer. The present surface layer corresponds in thickness to that of the plowed layer, and it is finer textured than the one in the uneroded Irwin silty clay loam. Some small areas have a light silty clay surface layer.

Included in mapping were small areas of Wymore silty clay loam, eroded, Tully silty clay loam, eroded, and Clime silty clay loam. Also included were areas of rock outcrops and small slick spots that are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area less than 1 acre in size. Each symbol shown for a slick spot represents an area less than 2 acres in size.

This soil has high available water capacity but takes in water slowly and releases it slowly for plant use. The soil is difficult to till, and surface crusting hinders emergence of seedlings in some places. Surface runoff is rapid, and the hazard of continued erosion is severe, especially in areas where protective cover is sparse.

Terracing and contour farming help to control erosion. Deep-rooted legumes improve the water intake. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to improve tilth of the surface layer.

Most areas of this soil are cultivated. Wheat and grain sorghum are the main crops. Some areas are seeded to bromegrass or reseeded to native grasses. Some areas are idle.

This soil is suited to native and tame grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IVe–1, Claypan range site, windbreak suitability group E)

Ivan Series

The Ivan series consists of deep, nearly level and gently sloping, calcareous soils on bottom lands along most creeks in the survey area and on a few alluvial fans. These soils formed in calcareous alluvium.

In a representative profile the surface layer is dark-gray silt loam and light silty clay loam about 26 inches thick. The layer between depths of 26 and 39 inches is grayish-brown light silty clay loam. The substratum is grayish-brown light silty clay loam.

Ivan soils are well drained to moderately well drained. They have moderate permeability.

Representative profile of Ivan silt loam in an area of Ivan and Kennebec silt loams, 2,490 feet north and 840 feet west of the southeast corner of sec. 32, T. 10 S., R. 9 E., in a cultivated field:

Ap—0 to 7 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; few roots; few worm casts; calcareous; moderately alkaline; clear, smooth boundary.

A1—7 to 26 inches, dark-gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine granular structure; slightly hard when dry, friable when moist; few roots; few worm casts; calcareous; moderately alkaline; gradual, smooth boundary.

AC—26 to 39 inches, grayish-brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; few worm casts; calcareous; moderately alkaline; gradual, smooth boundary.

C—39 to 64 inches, grayish-brown (10YR 5/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of dark yellowish brown (10YR 4/4); some thin strata of light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; massive; slightly hard when dry, friable when moist; calcareous; moderately alkaline.

The A1 and AC horizons, when dry, are gray, dark gray, grayish brown, or dark grayish brown. The C horizon ranges

from grayish brown and light brownish gray to brown and pale brown. The A1 and AC horizons range from silt loam to silty clay loam. Ivan soils are calcareous and moderately alkaline in all horizons below a depth of 10 inches, and they are calcareous to the surface in some places.

In some places the Ivan soils are mapped with Kennebec soils, and they are near the Reading soils on bottom lands along creeks. Ivan soils are more alkaline throughout the profile than Kennebec soils. They are more alkaline above a depth of 40 inches, less clayey in the lower part of the profile, and less strongly developed than the Reading soils.

Ivan silty clay loam, 1 to 3 percent slopes (Ie).—This soil is on alluvial fans in the Kansas River valley and in some of the larger creek valleys. The fans are below intermittent drainageways that flow out of the uplands. This soil has a profile that is similar to the one described as representative for the Ivan series, except that it has a silty clay loam surface layer. Fragments of limestone less than 1 inch in diameter generally are in one or more of the soil layers.

Included in mapping were some areas of Reading silt loam. These areas make up about 10 percent of the mapping unit.

This Ivan soil is easy to work. It takes in water well and readily releases it to plants. It has high available water capacity. Runoff is medium, and the soil will erode if not protected. Management is needed that controls water erosion and maintains good tilth and fertility.

Terracing and contour farming help to control erosion on this soil. Diversions are needed in some areas to intercept runoff from higher slopes. Good management of crop residues helps to prevent erosion and to keep the surface layer in condition to take water readily and to be worked easily.

The most common crops grown on this soil are wheat, grain sorghum, corn, and alfalfa.

This soil is well suited to native and tame perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit IIe–2, Loamy Upland range site, woodland suitability group 3, windbreak suitability group A)

Ivan and Kennebec silt loams (0 to 1 percent slopes) (Iv).—These soils are on the flood plains of most creeks and other streams in the survey area. They are generally nearly level, but some small areas are gently sloping.

These soils were not differentiated in mapping, because they are similar in their responses to use and management. Ivan silt loam makes up 10 to 90 percent of the mapping unit, and Kennebec silt loam makes up 10 to 90 percent. Both soils have the profiles described as representative for their respective series.

Included in mapping were small areas of Muir and Reading silt loams on the highest part of the bottomland area. Also included were small, poorly drained depressions that are shown on the detailed soil map by symbols. Each symbol represents an area smaller than 5 acres in size.

These soils are easily tilled. They absorb water well and release it readily for plant use. They have high available water capacity. Crops are occasionally damaged by flooding and by deposits of silt. Floodwaters readily recede as the streams subside. Maintenance of fertility and good tilth is the main concern of management on these soils.

These soils are suited to all crops commonly grown in the survey area. Grain sorghum, corn, alfalfa, and wheat are the main crops. Some soybeans are grown. Small grains are less suited than most other crops, because they tend to grow rank and to lodge before harvest time. Also, some damaging flooding occurs at or near harvest time. Any crop that produces sufficient vegetation growth can be grown continuously if the residues are returned to the soil and if weeds and insects are controlled. Crop residues returned to the soil keep the surface layer in condition to take water readily and to be tilled easily.

Dikes and diversions are useful in places for diverting floodwaters. Flooding can best be controlled by conservation measures that are applied upstream and by the use of flood control structures.

These soils also are well suited to tame and native perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit IIw–1, Loamy Lowland range site, woodland suitability group 1, windbreak suitability group A)

Kahola Series

The Kahola series consists of deep, nearly level soils on low terraces along the Kansas River. These soils formed in calcareous alluvium.

In a representative profile the surface layer is about 17 inches thick. It is grayish-brown silt loam in the upper part and dark-gray silt loam and silty clay loam in the lower part. Below the surface layer is dark-gray and grayish-brown silty clay loam that extends to a depth of 60 inches.

The Kahola soils are well drained, and they have moderate permeability.

Representative profile of Kahola silt loam, 1,810 feet north and 70 feet west of the southeast corner of sec. 17, T. 10 S., R. 9 E., in a cultivated field:

Ap—0 to 7 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish-brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; few roots; few worm casts; mildly alkaline, clear, smooth boundary.

A11—7 to 13 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; few roots; few worm casts; mildly alkaline; clear, smooth boundary.

A12—13 to 17 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine and very fine, subangular blocky structure; hard when dry, friable when moist; few roots; few worm casts; mildly alkaline; clear, smooth boundary.

AC1—17 to 32 inches, stratified, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) silty clay loam, very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist; few roots; few worm casts; mildly alkaline; gradual, smooth boundary.

AC2—32 to 43 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, very fine, subangular blocky structure; hard when dry, friable when moist; common pores; few worm casts; calcareous; moderately alkaline; gradual, smooth boundary.

A1b—43 to 60 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) when moist; few, fine, faint mottles of dark yellowish brown (10YR 4/4); massive; few, fine, soft threads of carbonate; calcareous; moderately alkaline.

The A horizon, when dry, is dark gray, dark grayish brown, or grayish brown. The AC and C horizons range from gray or dark gray to brown or pale brown. The horizons between depths of 10 and 40 inches range from silt loam to silty clay loam. Kahola soils range from neutral or mildly alkaline in the A1 horizon to mildly alkaline or moderately alkaline in the AC and C horizons. The depth to free carbonates ranges from 15 to 40 inches.

Kahola soils are near the Eudora, Haynie, and Muir soils and are on similar landscapes. They have a profile that is similar to that of the Reading soils. Kahola soils have horizons in the lower part of the profile that are more clayey than those of the Eudora, Haynie, and Muir soils. They are more alkaline above a depth of 40 inches than the Reading soils.

Kahola silt loam (0 to 1 percent slopes) (Ka).—This is the only Kahola soil mapped in the survey area.

Included in mapping were areas of soils that are similar to the Kahola soils, except that they are calcareous above a depth of 15 inches. These inclusions make up 10 to 25 percent of the mapping unit. Also included were small areas of Haynie very fine sandy loam and Eudora silt loam. Small depressions that have poor surface drainage, and also wet spots, are shown on the detailed soil map by symbols. Each symbol shown for a depression represents an area smaller than 5 acres in size. Each symbol shown for a wet spot represents an area smaller than 6 acres in size; here, the water table is within 3 feet of the surface.

This soil absorbs water well and releases it readily for plant use. It has high available water capacity. Some flooding occurs in some areas. Maintenance of fertility and good tilth is the main concern of management.

This soil is suited to all crops commonly grown in the survey area. Wheat, grain sorghum, alfalfa, corn, and soybeans are the main crops. Any crop that produces sufficient vegetation can be grown continuously if the residues are returned to the soil and if weeds and insects are controlled. Crop residues returned to the soil keep the surface layer in condition to take water readily and to be tilled easily.

This soil also is well suited to tame and native perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit I–1, Loamy Lowland range site, woodland suitability group 3, windbreak suitability group A)

Kenesaw Series

The Kenesaw series consists of deep, gently sloping and sloping soils on uplands. These soils formed in loess.

In a representative profile the surface layer is dark-gray silt loam in the upper part and dark grayish-brown silt loam in the lower part. The surface layer is about 12 inches thick. The subsoil extends to a depth of 36 inches. In the upper part the subsoil is brown silt loam that is slightly hard when dry and is friable when moist. The lower part of the subsoil is light-brown silt loam that is slightly hard when dry and is very friable when moist. The substratum is light-brown silt loam.

The Kenesaw soils are well drained. They are moderately permeable.

Representative profile of Kenesaw silt loam, 6 to 10 percent slopes, 1,700 feet north and 1,700 feet west of the southeast corner of sec. 6, T. 11 S., R. 7 E., in native grass:

A1—0 to 7 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, medium, granular structure; soft when dry, very friable when moist; common roots; few worm casts; neutral; clear, smooth boundary.

A3—7 to 12 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; slightly hard when dry, very friable when moist; common roots; few worm casts; slightly acid; clear, smooth boundary.

B1—12 to 17 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; common roots; few worm casts; slightly acid; clear, smooth boundary.

B2—17 to 36 inches, light-brown (7.5YR 6/4) silt loam, brown (7.5YR 4/4) when moist; weak, coarse, blocky structure; slightly hard when dry, very friable when moist; common roots; few worm casts; slightly acid; diffuse, smooth boundary.

C—36 to 60 inches, light-brown (7.5YR 6/4) silt loam, brown (7.5YR 5/4) when moist; massive; slightly hard when dry, very friable when moist; slightly acid.

The A horizon ranges in thickness from 7 inches in some cultivated areas to 16 inches in some grassland areas. The A1 horizon, when dry, is dark gray, very dark gray, dark grayish brown, or dark brown. The B horizon is brown or light brown. The C horizon is light brown or light yellowish brown. The B and C horizons are mainly silt loam, but they are very fine sandy loam in some places. Kenesaw soils range from medium acid to neutral in all horizons.

In Riley County, these soils are leached of carbonates to a greater depth than is within the range defined for the series. In addition, their B2 and C horizons are 7.5YR in hue and 4 in chroma, and this is outside the defined range for the series. These differences do not alter the usefulness and behavior of the soils.

Kenesaw soils are mapped near the Geary soils and are on similar landscapes. Kenesaw soils have a coarser textured B horizon than the Geary soils.

Kenesaw silt loam, 2 to 6 percent slopes (Ke).—This soil is on uplands near the Kansas and Republican River valleys. Included in mapping were small areas of Geary silt loam.

This Kenesaw soil takes water readily, and it has a high available water capacity. Water is readily released for plant use. Surface runoff is medium. The major concerns of management are control of erosion and maintenance of good tilth and fertility.

Terracing and contour farming help to control erosion. Good management of crop residues also help to control erosion and to keep the surface layer in good condition.

This soil is suited to all crops grown in the survey area. Wheat, grain sorghum, and alfalfa are the main crops grown. The soil also is suited to tame and native perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe–5, Loamy Upland range site, windbreak suitability group C)

Kenesaw silt loam, 6 to 10 percent slopes (Kf).—This soil is on uplands near the Kansas and Republican River valleys. It has the profile described as representative for the Kenesaw series.

Included in mapping were small areas of Geary silt loam.

This Kenesaw soil absorbs water well and releases it readily for plant use. It has high available water capacity. Surface runoff is medium to rapid in some cultivated areas, and erosion is a severe hazard. The major concerns of management are the control of erosion and the maintenance of fertility.

Terracing and contour farming help to control erosion. Good management of crop residues helps to maintain the surface layer in good condition and to control erosion.

Most areas of Kenesaw silt loam, 6 to 10 percent slopes, are in native grass. The most common crops grown are wheat and grain sorghum. This soil is suited to alfalfa and corn, to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IVe-2, Loamy Upland range site, windbreak suitability group C)

Kennebec Series

The Kennebec series consists of deep, nearly level soils on bottom lands along most creeks in the survey area. These soils formed in noncalcareous alluvium.

In a representative profile the surface layer is heavy silt loam about 18 inches thick. It is dark gray in the upper part and dark grayish brown in the lower part. The layer between depths of 18 and 46 inches is dark-gray light silty clay loam that is slightly hard when dry and is friable when moist. The substratum is grayish-brown light silty clay loam.

Kennebec soils are well drained to moderately well drained. They have moderate permeability.

In this county Kennebec soils are mapped only in an undifferentiated group with Ivan soils. A description of the mapping unit is given under the Ivan series.

Representative profile of Kennebec silt loam in an area of Ivan and Kennebec silt loams, 2,590 feet east and 125 feet south of the northwest corner of sec. 1, T. 11 S., R. 6 E., in a cultivated field:

A11—0 to 8 inches, dark-gray (10YR 4/1) heavy silt loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure and weak, fine, subangular blocky structure; slightly hard when dry, friable when moist; few roots; few worm casts; mildly alkaline; clear, smooth boundary.

A12—8 to 18 inches, dark grayish-brown (10YR 4/2) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, granular structure; slightly hard when dry, friable when moist; few pores; few worm casts; mildly alkaline; gradual, smooth boundary.

AC—18 to 46 inches, dark-gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; few pores; neutral; gradual, smooth boundary.

C—46 to 60 inches, grayish-brown (10YR 5/2) light silty clay loam; very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of dark yellowish brown (10YR 4/4); weak, fine, granular structure; slightly hard when dry, friable when moist; few pores; neutral.

The A and AC horizons, when dry, are dark gray, very dark gray, dark grayish brown, or very dark grayish brown. The C horizon ranges from gray or dark gray to grayish brown or dark grayish brown. The horizons between depths of 10 and 40 inches range from silt loam to silty clay loam. Kennebec soils are neutral or mildly alkaline to a depth of 40 inches.

In Riley County, these soils are about one reaction class less acid than the defined range for the series, but this difference does not alter their usefulness and behavior.

Kennebec soils are mapped with Ivan soils and are near the Reading soils on bottom lands along creeks. Kennebec soils are less alkaline throughout the profile than Ivan soils. They are less clayey in the lower part of the profile than the Reading soils and not so strongly developed as those soils.

Mayberry Series

The Mayberry series consists of deep, gently sloping and sloping soils on uplands. These soils formed in glacial outwash and reworked Kansan till.

In a representative profile the surface layer is dark-gray light clay loam in the upper part and dark grayish-brown clay loam in the lower part. This layer is about 13 inches thick. The subsoil, about 45 inches thick, is brown clay that is very hard when dry and is very firm when moist. The substratum is very pale brown heavy clay loam.

Mayberry soils are moderately well drained. They are slowly permeable.

Representative profile of Mayberry clay loam, 2 to 6 percent slopes, 1,665 feet west and 30 feet north of the southeast corner of sec. 19, T. 6 S., R. 7 E., in native grass:

A1—0 to 7 inches, dark-gray (10YR 4/1) light clay loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; many roots; few worm casts; medium acid; clear, smooth boundary.

A3—7 to 13 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; common roots; few worm casts; medium acid; clear, smooth boundary.

B21t—13 to 24 inches, brown (7.5YR 4/2) clay, dark brown (7.5YR 3/2) when moist and brown (7.5YR 4/2) when moist and rubbed; few, fine, faint mottles of yellowish red (5YR 4/6); weak, medium, blocky structure; very hard when dry, very firm when moist; few fine roots; few pebbles of quartz up to one-eighth inch in diameter; few concretions of iron and manganese; slightly acid; gradual, smooth boundary.

B22t—24 to 34 inches, brown (7.5YR 5/3) clay, dark brown (7.5YR 4/3) when moist; few, fine, faint mottles of yellowish red (5YR 5/6); weak, medium, blocky structure; very hard when dry, very firm when moist; few fine roots; few pebbles up to one-half inch in diameter; few concretions of iron and manganese; neutral; gradual, smooth boundary.

B31—34 to 43 inches, brown (7.5YR 5/4) clay, dark brown (7.5YR 4/4) when moist; weak, medium, blocky structure; very hard when dry, very firm when moist; few pebbles up to 1 inch in diameter; few concretions of iron and manganese; moderately alkaline; gradual, smooth boundary.

B32—43 to 58 inches, mixed brown (7.5YR 5/4) and very pale brown (10YR 7/3) clay, dark brown (7.5YR 4/4) and pale brown (10YR 6/3) when moist; few, fine, faint mottles of strong brown (7.5YR 5/6); weak, medium, blocky structure; very hard when dry, very firm when moist; few pebbles up to one-half inch in diameter; common concretions and stains of iron and manganese; moderately alkaline; gradual, smooth boundary.

C—58 to 64 inches, very pale brown (10YR 7/3) heavy clay loam, pale brown (10YR 6/3) when moist; common, fine and medium, distinct mottles of strong brown (7.5YR 5/6); weak, medium, blocky structure; very hard when dry, firm when moist; a few stains of iron and manganese on ped surfaces; few concretions of carbonate; moderately alkaline.

The solum ranges from 36 to 65 inches in thickness. A few glacial stones and pebbles are throughout the profile. The A1 horizon, when dry, ranges from dark gray or very dark gray to dark grayish brown. Depth to the B2t horizon ranges from 8 to 15 inches. The B2t horizon ranges from dark brown or reddish brown to light brown or light reddish brown when dry. The C horizon, when dry, ranges from light brown or pink to pale brown, light yellowish brown, or very pale brown. Concretions and threads of free carbonates are below a depth of 40 inches in some places. The Mayberry soils are medium acid or slightly acid in the A horizons, slightly acid or neutral in the B2 horizons, and mildly alkaline or moderately alkaline in the B3 and C horizons.

Mayberry soils are on landscapes that are similar to the landscapes of the Dwight, Irwin, and Wymore soils. In contrast to those soils, however, Mayberry soils have glacial pebbles in the profile.

Mayberry clay loam, 2 to 6 percent slopes (Ma).—This soil is on convex upland ridgetops and side slopes. It has the profile described as representative for the Mayberry series.

Included in mapping were small areas of Irwin silty clay loam. Also included were small severely eroded areas that are shown on the detailed soil map by symbols. Each symbol represents an area smaller than 5 acres in size.

This soil has high available water capacity, but the subsoil absorbs and releases water slowly. The clayey subsoil restricts the growth of roots. Surface runoff is medium. Management is needed to maintain soil structure and fertility and to increase the intake of water. Water erosion is the main management concern, but soil blowing also can be a concern if this soil is left bare during winter.

Terracing and contour farming help to control erosion in cultivated areas. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce water erosion and soil blowing, to increase the intake of water, and to maintain good tilth of the surface layer.

Most areas of Mayberry clay loam, 2 to 6 percent slopes, are used as rangeland or hay meadows. Some wheat, grain sorghum, and corn are grown. The soil generally is better suited to wheat and grain sorghum than to corn.

This soil also is suited to trees for windbreaks and to development as wildlife habitat. (Capability unit IIIe–1, Clay Upland range site, windbreak suitability group C)

Mayberry clay loam, 2 to 6 percent slopes, eroded (Mb).—This soil is on convex upland ridgetops and side slopes. It has a profile that is similar to the one described as representative for the Mayberry series, but water erosion has removed much of the original surface layer. Tillage has mixed subsoil material with the remaining part of the original surface layer. The present surface layer is heavy clay loam, and it corresponds in thickness to the plowed layer.

Included in mapping were small areas of Irwin silty clay loam, eroded.

This Mayberry soil has high available water capacity, but it takes in water slowly and releases it slowly for plant use. The soil is difficult to till, and surface crusting hinders emergence of seedlings in some places. Surface runoff is medium to rapid, and the hazard of continued erosion is severe.

Terracing and contour farming help to control erosion. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to improve the tilth of the surface layer.

The main crops grown on this soil are wheat and grain sorghum. This soil is suited to native and tame perennial grasses, to trees for windbreaks, and to the develpment of wildlife habitat. (Capability unit IIIe–6, Claypan range site, windbreak suitability group E)

Muir Series

The Muir series consists of deep, nearly level soils on river and creek terraces. These soils formed in deep alluvium.

In a representative profile the surface layer is grayish-brown silt loam about 18 inches thick. The subsoil extends to a depth of 42 inches. It is grayish-brown heavy silt loam that is slightly hard when dry and is friable when moist. The substratum is light brownish-gray silt loam.

The Muir soils are well drained. They have moderate permeability.

Representative profile of Muir silt loam, 2,640 feet west and 970 feet north of the southeast corner of sec. 30, T. 9 S., R. 8 E., in a cultivated field:

Ap—0 to 7 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; few roots and pores; few worm casts; neutral; clear, smooth boundary.

A1—7 to 18 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; few roots and pores; common worm casts; neutral; clear, smooth boundary.

B2—18 to 42 inches, grayish-brown (10YR 5/2) heavy silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; few roots and pores; few worm casts; slightly acid; gradual, smooth boundary.

C—42 to 60 inches, light brownish-gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) when moist; few, fine, faint mottles of dark yellowish brown; massive; slightly hard when dry, friable when moist; few roots and pores; mildly alkaline.

The solum ranges from 24 to 48 inches in thickness. The layers between depths of 10 and 40 inches are silt loam or light silty clay loam. In dry soil, grayish brown or brown extends to a depth of at least 20 inches and, in some places, to a depth of 48 inches. The C horizon ranges from grayish brown or brown to light gray or very pale brown. The Muir soils lack free carbonates above a depth of 48 inches. These soils are slightly acid to neutral in the A horizon and upper part of the B horizon and neutral to mildly alkaline in the C horizon.

Muir soils are mapped near the Eudora and Kahola soils, which are on bottom lands along rivers. They have a profile that is similar to that of Reading soils, which are on bottom lands along creeks. Muir soils are finer textured above

a depth of 40 inches than the Eudora soils, and they have a less clayey B horizon than the Kahola and Reading soils.

Muir silt loam (0 to 1 percent slopes) (Mu).—This is the only Muir soil mapped in the survey area.

Included in mapping were small areas of Reading silt loam and Eudora silt loam. Also included were small, poorly drained depressions that are shown on the map by symbols. Each symbol represents an area smaller than 5 acres in size.

Muir silt loam is rarely flooded, and it is easily tilled. It absorbs water well and releases it readily for plant use. The soil has high available water capacity. Maintenance of fertility and good tilth is the main concern of management.

This soil is well suited to all crops commonly grown in the survey area (fig. 14). Any crop that produces sufficient vegetation can be grown continuously if the residues are returned to the soil and if weeds and insects are controlled. Crop residues returned to the soil keep the surface layer in condition to take water readily and to be tilled easily.

This soil also is well suited to tame and native perennial grasses, to trees for windbreaks and for wood crops, and to development of wildlife habitat. (Capability unit I-1, Loamy Lowland range site, woodland suitability group 3, windbreak suitability group A)

Reading Series

The Reading series consists of deep, nearly level and gently sloping soils on stream terraces and foot slopes in creek valleys. These soils formed in alluvial sediments.

In a representative profile the surface layer is dark grayish-brown silt loam about 11 inches thick. The subsoil is about 41 inches thick. The upper part of the subsoil is dark grayish-brown light silty clay loam that is hard when dry and is friable when moist. In the middle part, the subsoil is dark grayish-brown heavy silty clay loam that is hard when dry and is firm when moist. The lower part is brown heavy silty clay loam that is hard when dry and is firm when moist. The substratum is brown silty clay loam.

The Reading soils are well drained. They have moderately slow permeability, and they rarely are flooded.

Representative profile of Reading silt loam, 0 to 1 percent slopes, 1,250 feet east and 725 feet north of the southwest corner of sec. 1, T. 11 S., R. 7 E., in a cultivated field:

A1—0 to 11 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; few worm casts; medium acid; clear, smooth boundary.

B1—11 to 20 inches, dark grayish-brown (10YR 4/2) light silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; hard when dry, friable when moist; few worm casts; medium acid; gradual, smooth boundary.

B2t—20 to 40 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure and fine subangular blocky structure; hard when dry, firm when moist; slightly acid; diffuse, smooth boundary.

B3—40 to 52 inches, brown (10YR 5/3) heavy silty clay loam, dark grayish brown (10YR 4/2) when moist;

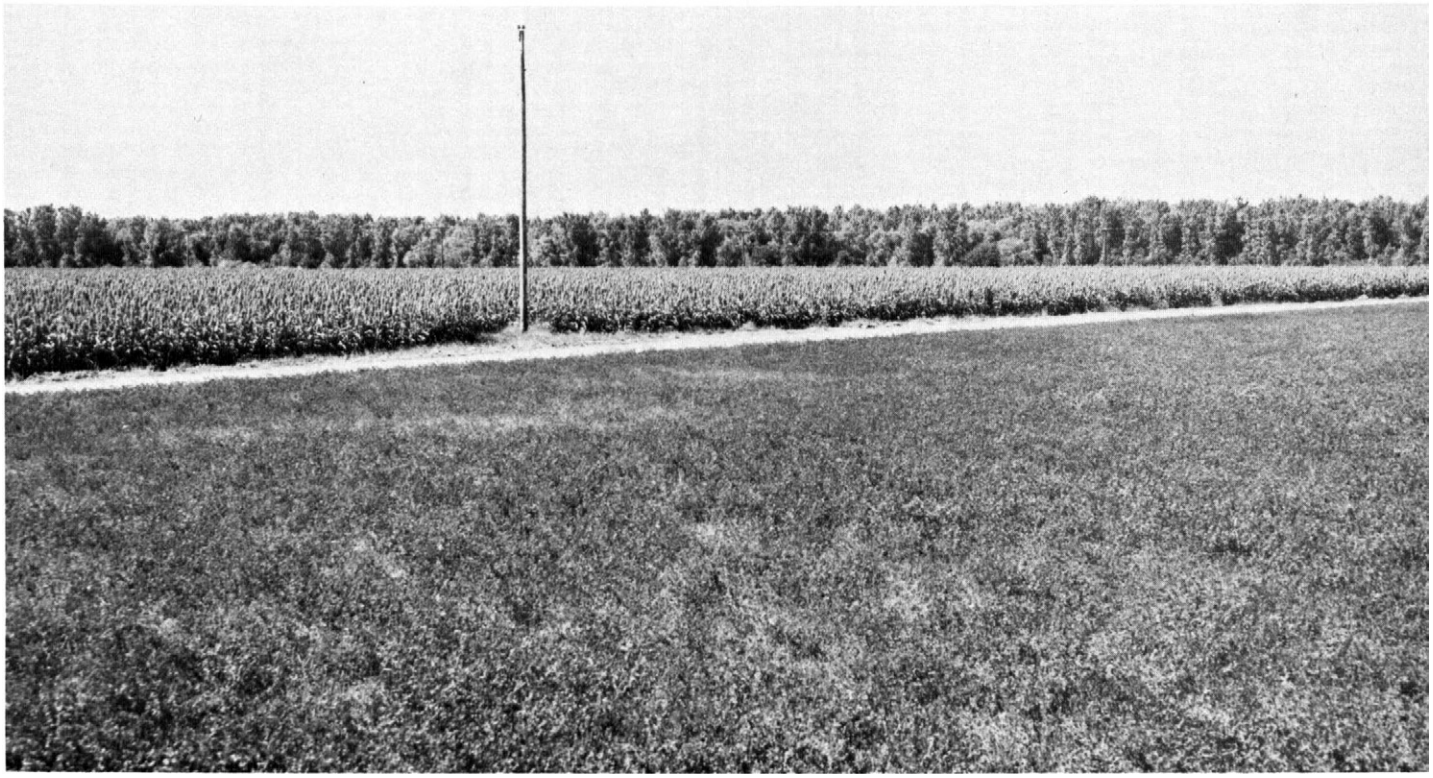

Figure 14.—Alfalfa and grain sorghum on Muir silt loam.

few, fine, faint mottles of yellowish brown; weak, fine, subangular blocky structure; hard when dry, firm when moist; neutral; diffuse, smooth boundary.

Cca—52 to 60 inches, brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) when moist; weak, fine, subanglar blocky structure; hard when dry, firm when moist; many threads and few concretions of carbonate; calcareous; moderately alkaline.

The solum ranges from about 40 to 65 inches in thickness. When dry, the A horizon ranges from very dark gray or very dark grayish brown to grayish brown. Depth to the B2t horizon ranges from 14 to 24 inches. The B horizons, when dry, range from very dark grayish brown or dark brown to grayish brown or brown. The B2t horizon is heavy silty clay loam or light silty clay. The C horizon ranges from grayish brown or light brownish gray to yellowish brown or light yellowish brown. These soils are medium acid or slightly acid in the A horizon, medium acid to neutral in the B horizon, and neutral to moderately alkaline in the C horizon. Depth to free carbonate is more than 40 inches.

Reading soils are mapped near Ivan, Kennebec, Chase, and Tully soils in creek valleys. They have profiles that are similar to those of the Kahola and Muir soils on the river bottom lands. Reading soils are more clayey in the lower part of the profile and are more strongly developed than Ivan and Kennebec soils. They are less clayey in the B2t horizon than the Chase and Tully soils. They are not so alkaline above a depth of 40 inches as the Kahola soils, and they have a more clayey B horizon than the Muir soils.

Reading silt loam, 0 to 1 percent slopes (Rd).—This soil is on terraces of most creeks in the survey area (fig. 15). It rarely is flooded. It has the profile described as representative for the Reading series.

Included in mapping were small areas of Muir silt loam and Chase silty clay loam. Also included were small, poorly drained depressions and areas of silt deposits 10 to 36 inches thick. These areas are shown on the detailed soil map by symbols. Each symbol shown for depressions represents an area smaller than 5 acres in size, and each symbol shown for silt deposits represents an area smaller than 6 acres.

Reading silt loam, 0 to 1 percent slopes, is easily tilled. It absorbs water well and releases it readily for plant use. The soil has high available water capacity. Surface runoff is slow. Maintenance of fertility and good tilth is the main concern of management.

Most of this soil is used for cultivated crops. The soil is well suited to all crops grown in the survey area. Corn and sorghums can be grown continuously if an adequate amount of crop residues is returned to the soil and if manure is added where silage is grown. Good management of crop residues keeps the surface layer in condition to take water readily and to be tilled easily.

This soil also is well suited to native and tame perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit I–2, Loamy Lowland range site, woodland suitability group 3, windbreak suitability group A)

Reading silt loam, 1 to 3 percent slopes (Re).—This soil is on foot slopes in the valleys of most creeks in the survey area. Included in mapping were small areas of Tully silty clay loam.

Reading silt loam, 1 to 3 percent slopes, is easy to till. It has high available water capacity. It takes water well and releases it readily for plant use. Surface runoff is medium. Management is needed that controls water erosion and maintains good tilth and fertility.

Terracing and contour farming help to control erosion. Good management of crop residues helps to prevent erosion and to keep the surface layer in condition to take water readily and to be worked easily.

The principal crops grown on this soil are wheat, grain sorghum, corn, and alfalfa.

Figure 15.—Area of Reading silt loam, 0 to 1 percent slopes, on a terrace along Wildcat Creek. Trees in the background are growing next to the creek channel.

This soil is well suited to native and tame perennial grasses, to trees for windbreaks and for woodland production, and to the development of wildlife habitat. (Capability unit IIe–2, Loamy Upland range site, woodland suitability group 3, windbreak suitability group A)

Sarpy Series

The Sarpy series consists of deep soils on the flood plains along the Kansas and Republican Rivers. These soils formed in alluvial sediments.

In a representative profile the surface layer is light brownish-gray loamy fine sand about 5 inches thick. Below the surface layer is a 6-inch layer of light-gray fine sand. The substratum is mostly light-gray fine sand. All layers below the surface layer are soft when dry and are very friable when moist.

Sarpy soils are excessively drained. Surface runoff is slow, but permeability is very rapid. Depth to the water table is more than 5 feet in most places.

Representative profile of Sarpy loam fine sand, 1,420 feet east and 220 feet south of the northwest corner of sec. 34, T. 10 S., R. 7 E., in an area of trees:

A1—0 to 5 inches, light brownish-gray (10YR 6/2) loamy fine sand, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist; few roots; calcareous; moderately alkaline; clear, smooth boundary.

AC—5 to 11 inches, light-gray (10YR 7/2) fine sand, dark grayish brown (10YR 4/2) when moist; massive; soft when dry, very friable when moist; calcareous; moderately alkaline; diffuse, smooth boundary.

C1—11 to 53 inches, light-gray (10YR 7/2) fine sand, grayish brown (10YR 5/2) when moist; single grained; loose when dry, loose when moist; few tree roots; calcareous; moderately alkaline; gradual, smooth boundary.

C2—53 to 60 inches, light brownish-gray (10YR 6/2) very fine sandy loam, dark grayish brown (10YR 4/2) when moist; weak, massive or single grained; soft when dry, very friable when moist; few tree roots; calcareous; moderately alkaline.

Layers of loamy fine sand and fine sand have a total thickness of more than 40 inches. When dry, the A horizon is grayish brown, light brownish gray, brown, or pale brown. The C horizon is light brownish gray, light gray, pale brown, or very pale brown.

Some Sarpy soils are mapped in a complex with Carr soils. Sarpy soils are coarser textured than Carr soils throughout the upper 40 inches of the profile.

Sarpy loamy fine sand (0 to 5 percent slopes) (Sa).—This soil is on flood plains along the Kansas and Republican Rivers, and it is nearly level to gently undulating. It has the profile described as representative for the Sarpy series.

Included in mapping were small areas of a soil that has a layer of sandy loam or clay loam between depths of 10 and 40 inches. Also included were small areas of dune land and small, poorly drained depressions that are shown on the map by symbols. Each symbol represents an area smaller than 5 acres in size.

This soil is excessively drained, and it has low available water capacity. Some areas are subject to flooding during periods of high rainfall. Soil blowing is a severe hazard in unprotected areas.

Maintaining a cover of grass or trees helps to control soil blowing and to decrease soil damage from minor flooding.

This soil is so droughty and subject to flood damage that it is not suited to cultivation. It is suited to native and tame perennial grasses, to trees for windbreaks and wood crops, and to development as wildlife habitat. (Capability unit VIe–5, Sands range site, woodland suitability group 4, windbreak suitability group H)

Smolan Series

The Smolan series consists of deep, gently sloping and sloping soils on high terraces and uplands near the valleys of the Kansas and Republican Rivers. These soils formed in loess.

In a representative profile the surface layer is dark-gray silt loam about 8 inches thick. The subsoil is 43 inches thick. The upper 9 inches of the subsoil is brown silty clay loam that is hard when dry and is friable when moist. The next 19 inches is reddish-brown heavy silty clay loam that is very hard when dry and is firm when moist. The lower 15 inches is brown silty clay. The substratum is light-brown silty clay loam.

Smolan soils are moderately well drained to well drained. They have slow permeability.

Representative profile of Smolan silt loam, 4 to 8 percent slopes, 1,930 feet west and 710 feet north of the southeast corner of sec. 10, T. 10 S., R. 7 E., in native grass:

A1—0 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; slightly hard when dry, very friable when moist; abundant roots; few worm casts; slightly acid; clear, smooth boundary.

B1—8 to 17 inches, brown (7.5YR 4/2) silty clay loam, dark brown (7.5YR 3/2) when moist; moderate, very fine, subanglar blocky structure; hard when dry, friable when moist; common roots; few worm casts; medium acid; clear, smooth boundary.

B21t—17 to 28 inches, reddish-brown (5YR 4/2) heavy silty clay loam, dark reddish brown (5YR 3/3) when moist; moderate, fine, blocky structure; very hard when dry, firm when moist; common roots; few black stains of iron and manganese; medium acid; gradual, smooth boundary.

B22t—28 to 36 inches, reddish-brown (5YR 5/4) heavy silty clay loam, reddish brown (5YR 4/4) when moist; moderate, medium, blocky structure; very hard when dry, firm when moist; few roots; few fine concretions of iron and manganese; medium acid; gradual, smooth boundary.

B3—36 to 51 inches, brown (7.5YR 5/4) silty clay loam, dark brown (7.5YR 4/4) when moist; weak, fine, blocky structure; very hard when dry, firm when moist; few roots; few fine concretions of iron and manganese; slightly acid; diffuse boundary.

C—51 to 60 inches, light-brown (7.5YR 6/4) silty clay loam, brown (7.5YR 5/4) when moist; few, fine, faint mottles; weak blocky structure; hard when dry, firm when moist; common, fine, black concretions of iron and manganese; neutral.

The solum ranges from 38 inches to more than 60 inches in thickness. When dry, the A1 horizon ranges from dark gray to brown in color. The B2t horizon ranges from dark grayish brown or brown in the upper layers to reddish brown or light reddish brown in the lower layers. The B2t horizon is heavy silty clay loam or light silty clay. Depth to a horizon that contains more than 40 percent clay is greater than 14 inches. Smolan soils are medium acid to neutral in the A horizon and in the B horizons.

In the mapping unit Smolan silty clay loam, 4 to 8 percent slopes, eroded, most areas have layers with a chroma of 4 within 20 inches of the surface. This is nearer the surface

than is within the range defined for the series, but this difference does not alter the usefulness or behavior of the soil.

Smolan soils are mapped near Geary and Wymore soils and are on similar landscapes. Smolan soils have a more clayey B horizon than the Geary soils, and they have a redder colored and less clayey B horizon than the Wymore soils.

Smolan silt loam, 1 to 4 percent slopes (Sm).—This soil is on convex, moderately broad ridgetops. Included with it in mapping were small areas of Wymore silty clay loam and Geary silt loam. Also included were small severely eroded areas that are shown on the detailed soil map by symbols. Each symbol represents an area smaller than 5 acres in size.

Smolan silt loam, 1 to 4 percent slopes, has high available water capacity. It takes water well if the surface layer is in good condition. The major management concerns are the control of erosion and the maintenance of fertility and soil tilth.

Terracing and contour farming help to control erosion. Good management of crop residues aids in controlling erosion and in keeping the surface layer in condition to take water readily and to be worked easily.

Most areas of this soil are used for native grass. This soil is suited to all crops commonly grown in the survey area. It also is well suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIe–1, Loamy Upland range site, windbreak suitability group C)

Smolan silt loam, 4 to 8 percent slopes (Sn).—This soil is on uplands that are below areas of Smolan silt loam, 1 to 4 percent slopes. It has the profile described as representative for the Smolan series.

Included in mapping were areas of Geary silt loam that make up about 20 percent of the mapping unit. Also included were rock outcrops, small severely eroded areas, and small areas of sandy soils. All of these areas are shown on the detailed soil map by symbols. Each symbol shown for rock outcrop represents an area smaller than 1 acre in size. Each symbol shown for an area of severely eroded soil represents an area less than 5 acres in size. Each symbol shown for a sandy soil represents an area less than 3 acres in size. The areas of sandy soil consist of materials that are sandy loam or coarser and are at least 20 inches deep.

This Smolan soil has high available water capacity. It takes water well if the surface layer is in good condition. Surface runoff is medium. The major management concerns are the control of erosion and the maintenance of fertility and soil tilth.

Terracing and contour farming help to control erosion on this soil. Good management of crop residues aids in controlling erosion and in keeping the surface layer in condition to take water readily and to be worked easily.

Most areas of this soil are used for native grass. This soil is suited to all crops commonly grown in the survey area. It also is well suited to tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe–1, Loamy Upland range site, windbreak suitability group C)

Smolan silty clay loam, 4 to 8 percent slopes, eroded (So).—This soil is on uplands. It has a profile that is similar to the one described as representative for the Smolan series, except that water erosion has removed most of the original surface layer. Tillage has mixed material from the subsoil with the remaining original surface layer. The present surface layer is silty clay loam, and in thickness it corresponds to the plowed layer.

Included in mapping were areas of Geary silt loam and of Smolan silt loam. These inclusions make up about 20 percent of the mapping unit. Also included were rock outcrops and small slick spots that are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area less than 1 acre in size. Each symbol shown for a slick spot represents an area less than 2 acres in size.

This soil has high available water capacity, but it takes in water slowly. Surface runoff is medium, and the potential for continued erosion is high. Management is needed that maintains soil structure and fertility and that increases the intake of water.

Terracing and contour farming help to control erosion on this soil. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to maintain good tilth of the surface layer.

Wheat, grain sorghum, and alfalfa are the principal crops grown on this soil. Corn and soybeans are grown on a small acreage. This soil is suited to native and tame perennial grasses, to trees for windbreaks, and to development of wildlife habitat. (Capability unit IIIe–6, Clay Upland range site, windbreak suitability group E)

Sogn Series

The Sogn series consists of shallow, sloping soils on uplands. These soils are underlain by limestone (fig. 16). They formed in residual material weathered from shale and limestone.

Sogn soils have a surface layer of dark-gray light silty clay loam about 9 inches thick. This layer rests on hard limestone bedrock.

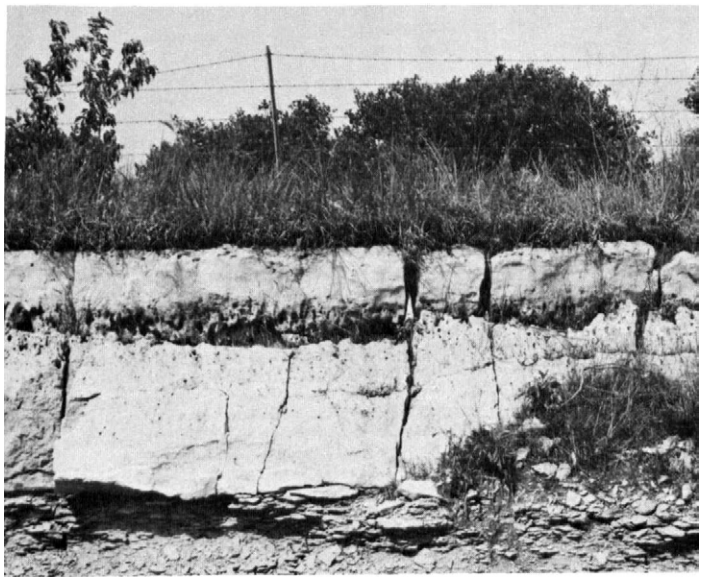

Figure 16.—**Profile of Sogn silty clay loam. This soil is about 5 inches thick over hard limestone.**

Sogn soils are somewhat excessively drained. They have moderate permeability.

In this county Sogn soils are mapped only in a complex with Clime soils. A description of the mapping unit is given under the Clime series.

Representative profile of Sogn silty clay loam in an area of Clime-Sogn complex, 5 to 20 percent slopes, 1,000 feet south and 30 feet west of the northeast corner of sec. 15, T. 9 S., R. 7 E., in native grass:

A1—0 to 9 inches, dark-gray (10YR 4/1) light silty clay loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; slightly hard when dry, friable when moist; many roots; common worm casts; few fragments of limestone less than one-half inch long; calcareous; moderately alkaline; abrupt boundary.

R—9 inches, limestone bedrock.

Depth to hard limestone bedrock ranges from 4 to 20 inches. The A horizon, when dry, ranges from gray or grayish brown to very dark gray or very dark grayish brown. Sogn soils range from slightly acid to moderately alkaline. They contain concretions of free carbonate and small fragments of limestone in some places.

Sogn soils are mapped in a complex with the Clime soils. They are on landscapes that are similar to the landscapes of the Florence soils. Sogn soils are shallower to bedrock than the Clime and Florence soils. Their profile lacks the chert that is characteristic of the Florence soils.

Stony Steep Land

Stony steep land (30 to 50 percent slopes) (St) consists of steep, shallow and moderately deep, medium-textured to fine-textured soils and limestone outcrops on uplands (fig. 17). It forms prominent valley walls along the sides of major stream valleys. Slopes generally are between 30 and 50 percent. The vertical interval from the base of the slope to the top of it ranges from 40 to 300 feet. The soils on the slope formed in residuum weathered from calcareous shales.

Runoff is very rapid, and the soils are excessively drained. Permeability is moderately slow to slow. The shallow soils have low available moisture capacity, and the moderately deep soils have moderate available moisture capacity.

Stony steep land is not suitable for cultivation. Native range is its best use, but some of it is not readily accessible for grazing by livestock because it is rough and steep. The native vegetation is mostly mid and tall

Figure 17.—Area of Stony steep land. The grain sorghum in the foreground is on Eudora silt loam.

prairie grasses, such as side-oats grama, little bluestem, big bluestem, indiangrass, and switchgrass. Many areas now have an overstory of brush and trees.

Careful management of grazing is needed to maintain or improve the combination of desirable forage plants and to control erosion.

Stony steep land is suited to the development of wildlife habitat. Trees that are suitable for windbreaks can be grown if the proper species are selected. (Capability unit VIIe–1, Breaks range site, windbreak suitability group F)

Sutphen Series

The Sutphen series consists of deep, nearly level soils on a terrace in the Kansas River valley. These soils formed in calcareous alluvium.

In a representative profile the upper part of the surface layer is a plowed layer about 6 inches thick. It is dark-gray light silty clay. The lower part of the surface layer is dark-gray silty clay about 30 inches thick. It is extremely hard when dry and extremely firm when moist. The substratum is grayish-brown calcareous silty clay that extends to a depth of more than 60 inches.

Sutphen soils are moderately well drained to somewhat poorly drained. Runoff is slow, and permeability is very slow. Slightly depressed areas are ponded for several days after heavy rains or snowmelt (fig. 18).

Representative profile of Sutphen silty clay, 2,110 feet east and 2,110 feet north of the southwest corner of sec. 21, T. 10 S., R. 9 E., in a cultivated field:

Ap—0 to 6 inches, dark-gray (10YR 4/1) light silty clay, black (10YR 2/1) when moist; moderate, fine and medium, granular structure; extremely hard when dry, firm when moist; slightly acid; abrupt, smooth boundary.

A1—6 to 36 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) when moist; moderate, fine and medium, blocky structure; extremely hard when dry, extremely firm when moist; few concretions of iron and manganese; slightly acid; gradual, smooth boundary.

C—36 to 60 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) when moist; common, faint, brown and very dark gray mottles on cut surfaces; moderate, fine, blocky structure; extremely hard when dry, extremely firm when moist; few concretions of iron and manganese; common concretions of carbonate; moderately alkaline.

All horizons above a depth of 5 feet are silty clay or clay. The horizons above a depth of 3 feet are very dark gray or dark gray when dry. The horizons below a depth of 3 feet are generally grayish brown. Reaction is neutral or slightly acid in the Ap horizon and is slightly acid to moderately alkaline in the A1 horizon. Depth to free carbonates is more than 20 inches.

Sutphen soils are similar to the Chase soils in their profile and position on the landscape. Sutphen soils have a more clayey A horizon than the Chase soils.

Sutphen silty clay (0 to 1 percent slopes) (Su).—This is the only Sutphen soil mapped in the survey area.

Included in mapping were areas of a soil that is similar to Sutphen silty clay, except that free carbonates are in the profile above a depth of 20 inches. These areas make up 15 to 30 percent of the mapping unit. Also included were small areas of Chase silty clay loam. Areas where silt deposits are 10 to 36 inches thick are shown on the detailed soil map by symbols. Each symbol represents an area less than 6 acres in size.

Sutphen silty clay takes water slowly and releases it slowly for plant use. Tillage is often delayed because water remains on the surface and because the soil dries slowly after rains. In dry periods the soil is somewhat droughty, forms wide cracks, and is difficult to till.

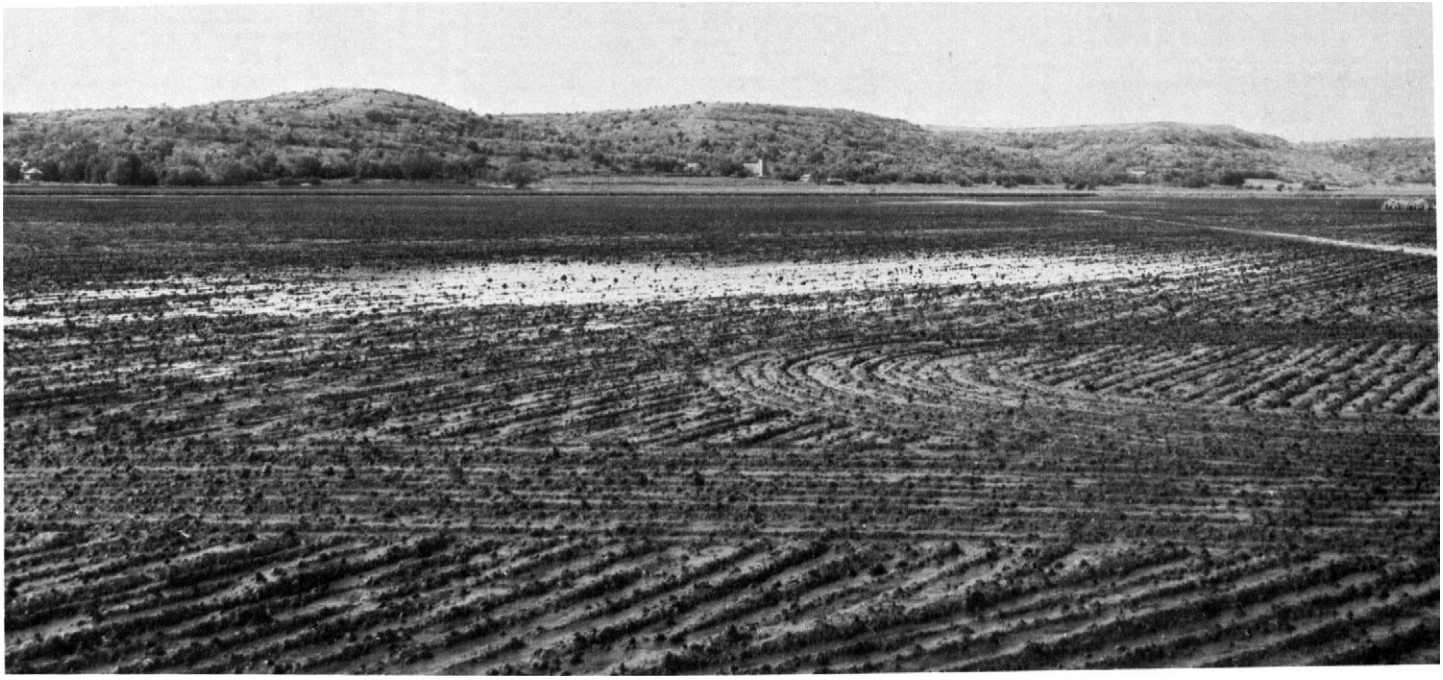

Figure 18.—**Ponded water on Sutphen silty clay. This soil has very slow permeability.**

Using open ditches and bedding improves surface drainage. Rough plowing in fall aids in aerating this soil. Good management of crop residues helps the surface layer to take more water, and it helps prevent soil blowing in spring.

This soil is suited to most crops grown in the county, except for alfalfa and corn. Alfalfa commonly is short-lived, and stands generally thin out or completely disappear within 2 or 3 years. Where an adequate drainage system is installed and maintained, however, alfalfa can be a dependable crop. Wheat, sorghum, and soybeans are the main crops grown (fig. 19).

This soil is suited to tame and native perennial grasses. It also is suited to trees for windbreaks, to woodland production, and to the development of wildlife habitat. (Capability unit IIIw–2, Clay Lowland range site, woodland suitability group 2, windbreak suitability group B)

Tully Series

The Tully series consists of deep, gently sloping and sloping soils on foot slopes. These soils formed in thick colluvial and alluvial deposits.

In a representative profile the surface layer is very dark gray silty clay loam about 10 inches thick. The subsoil is about 41 inches thick and consists of four different layers. The upper layer of the subsoil is very dark grayish-brown heavy silty clay loam. The next layer is dark grayish-brown silty clay. Next is a layer of grayish-brown silty clay. The lower layer is brown silty clay. The subsoil is very hard when dry and is firm when moist. The substratum is brown silty clay.

Tully soils are well drained. Their subsoil is slowly permeable.

Representative profile of Tully silty clay loam, 4 to 8 percent slopes, 2,340 feet north and 1,610 feet east of the southwest corner of sec. 11, T. 11 S., R. 8 E., in native grass:

A1—0 to 10 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; moderate, fine and medium, granular structure; hard when dry, friable when moist; many roots; few worm casts; slightly acid; clear, smooth boundary.

B1—10 to 16 inches, very dark grayish brown (10YR 3/2) heavy silty clay loam, very dark brown (10YR 2/2) when moist; moderate, fine and very fine, subangular blocky structure; very hard when dry, firm when moist; many roots; few worm casts; few fragments of chert less than one-half inch in diameter; medium acid; clear, smooth boundary.

B21t—16 to 28 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; common roots; few fragments of chert less than one-fourth inch in diameter; few, fine, black concretions; slightly acid; gradual, smooth boundary.

B22t—28 to 43 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) when moist; few, fine, faint mottles of yellowish brown; moderate, medium, blocky structure breaking to weak, fine and very fine, blocky; very hard when dry, firm when moist; few roots; few fragments of chert less than 1 inch in diameter; few, fine, black concretions; mildly alkaline; gradual, smooth boundary.

B3—43 to 51 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) when moist; few, fine, faint mottles of yellowish brown; weak, fine, blocky structure; very hard when dry, firm when moist; few fragments of chert less than one-half inch in diameter; few, fine, black concretions; mildly alkaline; gradual, smooth boundary.

C—51 to 60 inches, brown (7.5YR 4/4) silty clay, reddish brown (5YR 4/4) when moist; few medium mottles of reddish brown (5YR 5/4); massive; very hard when dry, firm when moist; few fragments of chert less than one-half inch in diameter; few, fine, black concretions; mildly alkaline.

Figure 19.—Field of matured soybeans. The soil in the foreground is Sutphen silty clay.

The solum ranges from 36 to 65 inches in thickness. Depth to bedrock is more than 40 inches. The A horizon ranges from very dark gray to dark grayish brown in color and from 7 to 14 inches in thickness. Depth to a horizon containing more than 40 percent clay ranges from 14 to 22 inches. The B21t horizon is dark grayish brown to brown, and the B22t is dark grayish brown to light brown or light yellowish brown. Tully soils range from medium acid to neutral in the A horizon, from slightly acid to moderately alkaline in the B2t horizon, and from neutral to moderately alkaline in the C horizon.

Tully soils formed in parent material that is similar to that of the Benfield soils. They are on landscapes that are similar to those of some Reading soils, and they have a profile that is similar to that of the Irwin soils. Tully soils are also near the Benfield, Reading, and Irwin soils. Tully soils are deeper to bedrock than the Benfield soils, they have more clayey B2t and C horizons than the Reading soils, and they are deeper to a silty clay B2t than the Irwin soils.

Tully silty clay loam, 1 to 4 percent slopes (Ts).—This soil is on plane or slightly concave foot slopes. Included with it in mapping were small areas of Irwin silty clay loam, Wymore silty clay loam, and Reading silt loam. Also included were small severely eroded areas that are shown on the detailed soil map by symbols. Each symbol represents an area less than 5 acres in size.

This soil has high available water capacity. It takes water well if the surface layer is in good condition. The major management concerns are the control of erosion and the maintenance of fertility and good soil tilth.

Terracing and contour farming help to control erosion. Good management of crop residues aids in controlling erosion and in keeping the surface layer in condition to take water readily and to be worked easily.

Tully silty clay loam, 1 to 4 percent slopes, is suited to all crops commonly grown in Riley County. Wheat, grain, sorghum, and alfalfa are the main crops.

This soil is well suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIe–1, Loamy Upland range site, windbreak suitability group C)

Tully silty clay loam, 1 to 4 percent slopes, eroded (Tt).—This soil is on plane or slightly concave foot slopes. It has a profile that is similar to the one described as representative for the Tully series, except that water erosion has removed much of the original surface layer. In most places tillage has mixed subsoil material with the remaining part of the original surface layer. The present surface layer corresponds with the plowed layer in thickness, and it is finer textured than the surface layer of uneroded Tully silty clay loam. Some small areas have a light silty clay surface layer.

Included in mapping were small areas of Irwin silty clay loam, eroded, Wymore silty clay loam, eroded, and Reading silt loam.

This Tully soil has high available water capacity, but it takes in water slowly and releases it slowly for plant use. Surface runoff is medium, and the potential for continued erosion is moderate. Management is needed that maintains soil structure and fertility and increases the intake of water.

Terracing and contour farming help to control erosion. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to aid in improving tilth of the surface layer.

Wheat, grain sorghum, alfalfa, and corn are the main crops grown on this soil. The soil is well suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe–2, Clay Upland range site, windbreak suitability group E)

Tully silty clay loam, 4 to 8 percent slopes (Tu).—This soil is on slightly concave foot slopes. It has the profile described as representative for the Tully series.

Included in mapping were small areas of Irwin silty clay loam and Clime silty clay loam. These included soils generally are near the upper part of the foot slope. Also included are rock outcrops, severely eroded areas, and slick spots that are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area smaller than 1 acre in size. Each symbol shown for a severely eroded area represents an area less than 5 acres in size. Each symbol shown for a slick spot represents an area less than 2 acres in size.

This soil has high available water capacity. It takes water well if the surface layer is in good condition. The major management concerns are the control of erosion and the maintenance of fertility and soil tilth.

Terracing and contour farming help to control erosion on this soil. Good management of crop residues aids in controlling erosion and in keeping the surface layer in condition to take water readily and to be worked easily.

Tully silty clay loam, 4 to 8 percent slopes, is suited to all crops commonly grown in Riley County. Wheat, grain sorghum, and alfalfa are the main crops grown (fig. 20).

This soil is well suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe–1, Loamy Upland range site, windbreak suitability group C)

Tully silty clay loam, 4 to 8 percent slopes, eroded (Tv).—This soil is on slightly concave foot slopes. It has a profile that is similar to the one described as representative for the Tully series, except that water erosion has removed much of the original surface layer. In most places tillage has mixed subsoil material with the remaining part of the surface layer. The present surface layer corresponds with the plowed layer in thickness and is finer textured than the surface layer of uneroded Tully silty clay loam. Some small areas have a light silty clay surface layer.

Included in mapping were small areas of Irwin silty clay loam, eroded, and of Clime silty clay loam. These included soils generally are near the upper part of the foot slope. Also included are rock outcrops that are shown on the detailed soil map by symbols. Each symbol represents an area less than 1 acre in size.

This soil has high available water capacity, but it takes in water slowly and releases it slowly for plant use. Surface runoff is medium to rapid, and the potential for continued erosion is high. Management is needed to maintain soil structure and fertility and to increase the intake of water.

Terracing and contour farming help to control erosion on this soil. Deep-rooted legumes improve the water intake. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to improve tilth of the surface layer.

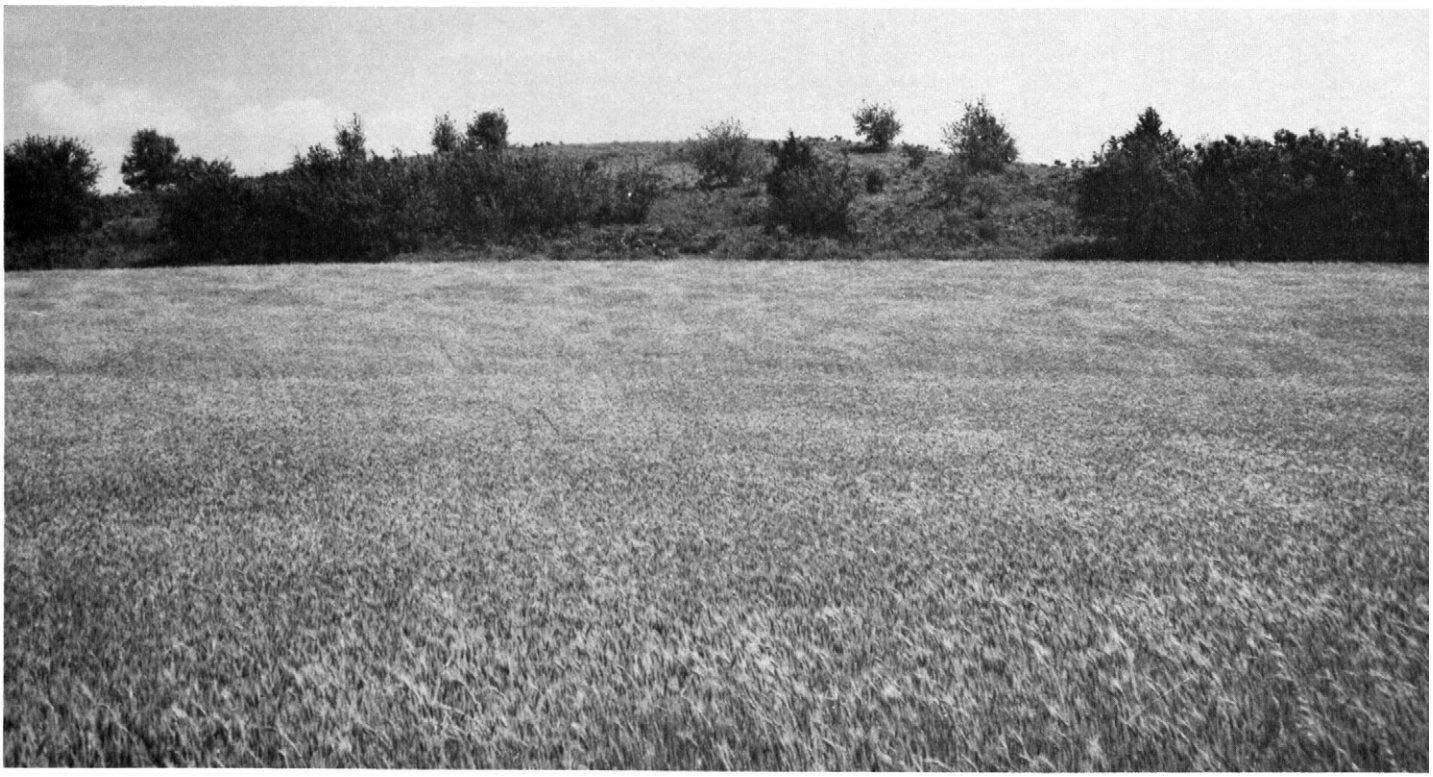

Figure 20.—Wheat on Tully silty clay loam, 4 to 8 percent slopes.

Wheat, grain sorghum, corn, and alfalfa are the main crops grown on Tully silty clay loam, 4 to 8 percent slopes, eroded. The soil also is suited to native and tame grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe-6, Clay Upland range site, windbreak suitability group E)

Wymore Series

The Wymore series consists of deep, nearly level to sloping soils on uplands. These soils formed in loess. Figure 21 shows a profile of a Wymore silty clay loam.

In a representative profile the surface layer is dark-gray silty clay loam about 13 inches thick. The subsoil is about 26 inches thick. It is dark grayish-brown silty clay in the upper part, grayish-brown silty clay in the middle part, and grayish-brown silty clay loam in the lower part. In the upper and middle parts it is very hard when dry and is firm when moist. The lower part is hard when dry and is firm when moist. The substratum is light brownish-gray silty clay loam to a depth of about 58 inches. Below this is brown silty clay loam.

Wymore soils are well drained to moderately well drained. Their subsoils are slowly permeable.

Representative profile of Wymore silty clay loam, 1 to 4 percent slopes, 2,640 feet north and 270 feet west of the southeast corner of sec. 14, T. 8 S., R. 5 E., in native grass:

A1—0 to 7 inches, dark-gray (10YR 4/1) light silty clay loam, black (10YR 2/1) when moist; weak, medium, granular structure; slightly hard when dry, friable when moist; common roots; few worm casts; slightly acid; clear, smooth boundary.

A3—7 to 13 inches, dark-gray (10YR 4/1) silty clay loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, subangular blocky and granular structure; hard when dry, friable when moist; common very fine roots; few worm casts; medium acid; clear, smooth boundary.

B21t—13 to 24 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; moderate, fine and medium, blocky structure; very hard when dry, firm when moist; few very fine roots; few, small, black concretions of iron and manganese; neutral; clear, smooth boundary.

B22t—24 to 33 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) when moist; few, fine, distinct mottles of yellowish red (5YR 5/8); moderate, fine and medium, blocky structure; very hard when dry, firm when moist; few very fine roots; few concretions and coatings of iron and manganese; neutral; clear, smooth boundary.

B3ca—33 to 39 inches, grayish-brown (10YR 5/2) heavy silty clay loam, dark grayish brown (10YR 4/2) when moist; common, fine, distinct mottles of yellowish red (5YR 5/8); moderate, fine and medium, blocky structure; hard when dry, firm when moist; few very fine roots; few concretions of carbonate; mildly alkaline; clear, smooth boundary.

C—39 to 58 inches, light brownish-gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) when moist; common, medium, distinct mottles of yellowish red (5YR 5/8); weak, medium and coarse, blocky structure; hard when dry, friable when moist; mildly alkaline; gradual, smooth boundary.

Ab—58 to 64 inches, brown (7.5YR 5/2) silty clay loam, dark brown (7.5YR 4/2) when moist; common, medium, distinct mottles of yellowish red (5YR 5/8); massive; hard when dry, friable when moist; mildly alkaline.

The solum ranges from 36 to 50 inches in thickness. Depth to a silty clay horizon ranges from 7 to 15 inches.

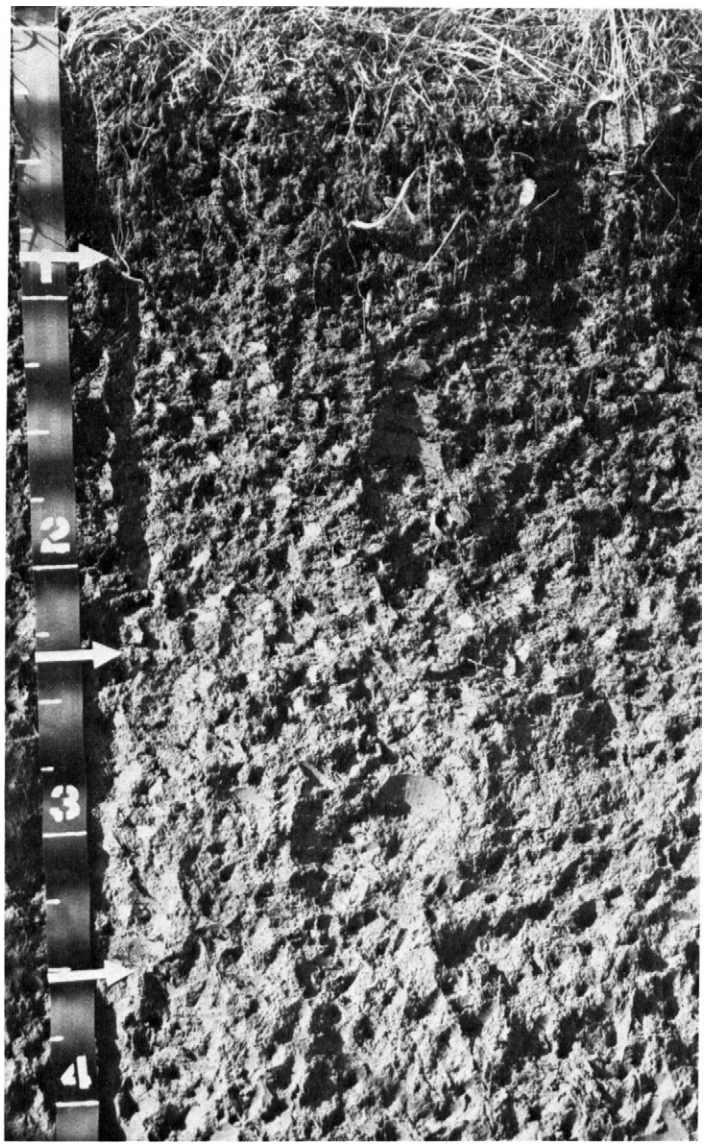

Figure 21.—**Profile of a Wymore silty clay loam. The surface layer is dark in color and is friable. It overlies a firm subsoil that contains an accumulation of clay.**

When dry, the A horizon ranges from dark gray to dark grayish brown. The B horizons range from 19 to 36 inches in combined thickness. When dry, they are dark grayish brown to grayish brown in the upper part and grayish brown to brown in the lower part. The C horizon commonly is light brownish gray, but in some places it is grayish brown, pale brown, or brown. Wymore soils are medium acid or slightly acid in the A horizons, slightly acid or neutral in the B2 horizon, and neutral or mildly alkaline in the B3 and C horizons. Carbonate concretions are below a depth of 25 inches in some places.

Wymore soils are on landscapes that are similar to those of the Dwight, Irwin, Smolan, and Mayberry soils. Wymore soils have a less clayey C horizon than the Dwight and Irwin soils, they have B and C horizons that are not so red as those of the Smolan soils, and they do not have the glacial pebbles that are characteristic of the Mayberry soils.

Wymore silty clay loam, 0 to 1 percent slopes (Wm).—This soil is on high uplands. Included with it in mapping were some areas of soils that are similar to Wymore soils, except that the dark-gray color of the surface layer extends deeper into the profile than it does in the Wymore soils.

This soil has high available water capacity. The fine-textured subsoil is slow in absorbing and releasing water, and it restricts the growth of roots.

Runoff is slow, and water commonly ponds for a short period after heavy rains. Management is needed that maintains soil structure and fertility and increases the intake of water.

Good management of crop residues aids in maintaining good tilth of the surface layer and in increasing the intake of water. Deep-rooted legumes also improve the ability of the soil to take water.

This soil is suited to all crops common to Riley County. Wheat and grain sorghum are the principal crops.

Wymore silty clay loam, 0 to 1 percent slopes, also is suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIs–1, Loamy Upland range site, windbreak suitability group C)

Wymore silty clay loam, 1 to 4 percent slopes (Wn).—This soil is on wide, convex tops and sides of ridges (fig. 22). It has the profile described as representative for the Wymore series.

Included in mapping were small areas of Irwin silty clay loam. Also included were rock outcrops and small severely eroded areas. These areas are shown on the detailed soil map by symbols. Each symbol shown for a rock outcrop represents an area less than 1 acre in size. Each symbol shown for a severely eroded area represents an area less than 5 acres in size.

This soil has high available water capacity. It takes water well if the surface layer is in good condition. The major management concerns are the control of erosion and the maintenance of fertility and soil tilth.

Terracing and contour farming help to control erosion. Good management of crop residues aids in controlling erosion and in keeping the surface layer in condition to take water readily and to be worked easily.

Wymore silty clay loam, 1 to 4 percent slopes, is suited to all crops commonly grown in the survey area. Wheat and grain sorghum are the main crops.

This soil also is well suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIe–1, Loamy Upland range site, windbreak suitability group C)

Wymore silty clay loam, 1 to 4 percent slopes, eroded (Wo).—This soil is on convex tops and sides of ridges. It has a profile that is similar to the one described as representative for the Wymore series, except that water erosion has removed much of the original surface layer. In most places tillage has mixed subsoil material with the remaining part of the original surface layer. The thickness of the present surface layer corresponds to that of the plowed layer, and the surface layer is finer textured than that of uneroded Wymore silty clay loam. Some small areas have a light silty clay surface layer.

Included in mapping were small areas of Irwin silty clay loam, eroded. Also included were rock outcrops and small slick spots that are shown on the detailed soil map by symbols. Each symbol shown for a rock

Figure 22.—Area of Wymore silty clay loam, 1 to 4 percent slopes.

outcrop represents an area less than 1 acre in size. Each symbol shown for a slick spot represents an area less than 2 acres in size.

This soil has high available water capacity, but it takes in water slowly and releases it slowly for plant use. Surface runoff is medium, and the potential for continued erosion is moderate. Management is needed to maintain soil structure and fertility and to increase the intake of water.

Terracing and contour farming help to control erosion. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to improve the tilth of the surface layer.

Wymore silty clay loam, 1 to 4 percent slopes, eroded, is generally used for wheat, grain sorghum, and alfalfa. Some corn is grown. This soil is well suited to native and tame perennial grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe–2, Clay Upland range site, windbreak suitability group E)

Wymore silty clay loam, 4 to 8 percent slopes (Wr).—This soil has convex or plane slopes. Included with it in mapping were small areas of Irwin silty clay loam. Also included were small severely eroded areas and rock outcrops that are shown on the map by symbols. Each symbol for a severely eroded area represents an area smaller than 5 acres in size. Each symbol shown for a rock outcrop represents an area less than 1 acre in size.

This soil has high available water capacity. It takes water well if the surface layer is in good condition. The major management concerns are the control of erosion and the maintenance of fertility and soil tilth.

Terracing and contour farming help to control erosion. Good management of crop residues aids in controlling erosion and in keeping the surface layer in condition to take water readily and to be worked easily.

This soil is generally used for rangeland and for hayland. It is well suited to wheat and grain sorghum. It also is suited to trees for windbreaks and to the development of wildlife habitat. (Capability unit IIIe–1, Loamy Upland range site, windbreak suitability group C)

Wymore silty clay loam, 4 to 8 percent slopes, eroded (Ws).—This soil has convex or plane slopes. It has a profile that is similar to the one described as representative for the Wymore series, except that water erosion has removed much of the original surface layer. In most places tillage has mixed subsoil material with the remaining part of the surface layer. The thickness of the present surface layer corresponds to that of the plowed layer, and the surface layer is finer textured than the one in uneroded Wymore silty clay loam. Some small areas have a light silty clay surface layer.

Included in mapping were small areas of Irwin silty clay loam, eroded. Also included were slick spots and rock outcrops that are shown on the map by symbols. Each symbol shown for a slick spot represents an area less than 2 acres in size. Each symbol shown for a rock outcrop represents an area less than 1 acre in size.

This soil has high available water capacity, but it takes in water slowly and releases it slowly for plant use. Surface runoff is medium, and the potential for continued erosion is high. Management is needed that maintains soil structure and fertility and increases the intake of water.

Terracing and contour farming help to control erosion. Deep-rooted legumes improve the intake of water. Good management of crop residues helps to reduce erosion, to increase the intake of water, and to improve the tilth of the surface layer.

Wheat and grain sorghum are the main crops grown on this soil. Corn and alfalfa are grown on a small acreage. The soil also is suited to native and tame grasses, to trees for windbreaks, and to the development of wildlife habitat. (Capability unit IIIe–6, Clay Upland range site, windbreak suitability group E)

Use and Management of Soils

The soils of Riley County and part of Geary County are used mostly for dryland farming and for range. This section explains how the soils can be managed for these main uses and gives the predicted yields of the principal dryland crops. In addition, it explains how the soils can be managed for woodland and windbreaks, wildlife habitat, and recreation uses. It also discusses suitability of the soils for building highways, farm ponds, and other engineering structures.

Use of Soils for Crops [2]

Using and properly managing soils for crops in the survey area will, over a period of years, result in good returns without lowering the productivity of the soil. If a soil is managed properly, it is used for the crop or purposes to which it is best suited. Improved management reduces the loss of organic matter in cultivated soils. Good management of crop residues is important to the maintenance of good soil structure, infiltration and percolation of water, and reduction of erosion. Using deep-rooted legumes, such as alfalfa and sweetclover, improves the intake of water. Varying the depth of tillage prevents the formation of a plowpan.

To conserve cultivated soils, management is needed that includes a suitable cropping system, minimum tillage, and optimum use of fertilizer and lime. Manure and crop residues should be returned to the soil to maintain or improve soil structure and tilth. Terracing, contour farming, and using grassed waterways reduce erosion on sloping soils. Drainage systems are needed on some lowland soils and occasionally on some upland soils. On most soils, good management consists of a combination of practices.

Wheat, sorghum, alfalfa, soybeans, and corn are the crops commonly grown in the survey area. These crops respond well to the use of commercial fertilizer, lime, and manure on most cultivated soils. The kind and amount of fertilizer used for a crop can best be determined by soil tests, field trials, and observations.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

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

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–3 or IIIe–6. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability classes, subclasses, and units in the survey area are defined (*12*).[3] The unit designation for each soil in the survey area can be found in the "Guide to Mapping Units" at the back of this survey.

Class I soils have few limitations that restrict their use.

Unit 1–1.—Deep, nearly level, well-drained soils that are medium textured throughout; on stream terraces.

[2] By Earl J. Bondy, conservation agronomist, Soil Conservation Service.

[3] Italicized numbers in parentheses refer to Literature Cited, page 69.

Unit I–2.—Deep, nearly level, well-drained, medium-textured soils that have a moderately fine textured subsoil; on creek terraces.

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

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

Unit IIe–1.—Deep, gently sloping, well drained and moderately well drained, medium-textured and moderately fine textured soils that have a moderately fine textured and fine textured subsoil; on high terraces, foot slopes, and uplands.

Unit IIe–2.—Deep, gently sloping, well drained and moderately well drained, medium-textured and moderately fine textured soils that have a moderately fine textured subsoil; on foot slopes and alluvial fans.

Unit IIe–3.—Deep, gently sloping, well-drained, medium-textured soils that have a moderately fine textured subsoil; on uplands.

Subclass IIw soils have moderate limitations because of excess water.

Unit IIw–1.—Deep, nearly level, medium-textured soils that are subject to frequent flooding; on creek bottoms.

Unit IIw–2.—Deep, nearly level, moderately well drained to somewhat poorly drained, moderately fine textured soils that have a fine textured subsoil; on terraces of large streams.

Subclass IIs soils have moderate limitations because of some factor in the soil root zone.

Unit IIs–1.—Deep, nearly level, well drained to moderately well drained, moderately fine textured soils that have a fine textured subsoil; on uplands.

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

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

Unit IIIe–1.—Deep, gently sloping and sloping, well drained to moderately well drained, medium-textured and moderately fine textured soils that have a moderately fine textured and fine textured subsoil; on foot slopes and uplands.

Unit IIIe–2.—Deep, gently sloping, well drained to moderately well drained, eroded soils that have a moderately fine textured surface layer and a fine textured subsoil; on foot slopes and uplands.

Unit IIIe–3.—Deep, gently sloping, well drained to moderately well drained, medium-textured and moderately fine textured soils that have a dense, fine textured subsoil; on uplands.

Unit IIIe–4.—Deep, gently sloping, well drained to moderately well drained, eroded soils that have a moderately fine textured surface layer and a dense, fine textured subsoil; on uplands.

Unit IIIe–5.—Deep, gently sloping and sloping, well-drained, medium-textured soils that have a medium-textured or moderately fine textured subsoil; on uplands.

Unit IIIe–6.—Deep, gently sloping and sloping, well drained to moderately well drained, moderately fine textured soils that have a moderately fine textured and fine textured subsoil; on foot slopes and uplands.

Subclass IIIw soils have severe limitations because of excess water.

Unit IIIw–1.—Deep, nearly level, moderately well drained to excessively drained soils that are moderately coarse textured and coarse textured in their surface layer and subsoil; on flood plains along rivers.

Unit IIIw–2.—Deep, nearly level, moderately well drained to somewhat poorly drained soils that are clayey throughout; on terraces along rivers.

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

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

Unit IVe–1.—Deep, sloping, well drained to moderately well drained, eroded soils that have a moderately fine textured surface layer and a fine textured subsoil; on uplands.

Unit IVe–2.—Deep, sloping, well-drained soils that are medium textured throughout; on uplands.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover. (None in survey area.)

Class VI soils have severe limitations that make them generally unsuited to cultivation without major reclamation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Subclass VIe soils have severe limitations because of susceptibility to erosion.

Unit VIe–1.—Moderately deep and shallow, sloping and moderately steep, well-drained to somewhat excessively drained, moderately fine textured soils; on uplands.

Unit VIe–2.—Moderately deep, sloping and moderately steep, well-drained cherty soils that have a fine-textured subsoil; on uplands.

Unit VIe–3.—Deep, nearly level to steep, medium-textured and moderately fine textured soils along intermittent drainageways.

Unit VIe–4.—Deep and moderately deep, sloping and moderately steep, well drained to moderately well drained, medium-textured and moderately fine textured soils that have a moderately fine textured subsoil; on uplands.

Unit VIe–5.—Deep, nearly level to gently undulating, excessively drained soils that are coarse textured throughout; on flood plains along rivers.

Subclass VIw soils have severe limitations because of excess water.

Unit VIw–1.—Deep, nearly level to sloping, medium-textured and moderately fine textured, frequently flooded soils; on flood plains

that are cut into many small parts by steam channels.

Class VII soils have very severe limitations that make them unsuited to cultivation without major reclamation and that restrict their use largely to range, woodland, or wildlife habitat.

Subclass VIIe soils have very severe limitations because of susceptibility to erosion.

Unit VIIe–1.—Shallow and moderately deep, steep soils and limestone outcrops; on uplands.

Class VIII soils and landforms have limitations that preclude their use for commercial plant production without major reclamation and that restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes. (None in survey area.)

Predicted yields

Predicted yields of the main crops grown under a high level of management in the survey area are shown in table 2. The predictions are averages for a period long enough to include both good and bad years. Yields are considerably higher than these averages in years when the temperature and moisture conditions are favorable, and they are lower in years when temperature and moisture conditions are unfavorable.

The yields are only estimates, because long-term records are not available. They were made on the basis of data obtained from farmers, agricultural technicians, the Kansas Agricultural Experiment Station, and observations of the soil survey party. No predictions are given for soils normally considered unsuitable for crops.

Table 2 shows the yields that can be expected under a high level of management. This kind of management includes (1) planting varieties of crops that are adapted to the area; (2) using proper seeding rates, planting at the right time, and using efficient methods of planting and harvesting; (3) providing for control of weeds, insects, and plant diseases sufficient to insure normal plant growth; (4) applying, at proper times, the kinds and amounts of fertilizer and lime indicated by soil tests; (5) establishing terraces and grassed waterways, farming on the contour, and using other practices that conserve moisture and help to control erosion; (6) establishing surface drainage where needed; (7) using methods of residue management and tillage that are designed to control erosion, preserve soil structure, increase the intake of water, and favor seedling emergence; and (8)

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

[The absence of a soil from this table indicates that these crops are not commonly grown on that soil]

Soil name	Corn	Grain sorghum	Wheat	Alfalfa	Bromegrass
	Bu.	*Bu.*	*Bu.*	*Tons*	*A.U.M.*[1]
Carr-Sarpy complex	64	70	30	3.6	4.0
Chase silty clay loam	76	84	44	4.4	7.1
Dwight-Irwin complex, 1 to 4 percent slopes	46	54	30	3.0	4.0
Dwight-Irwin complex, 1 to 4 percent slopes, eroded	40	48	26	2.6	3.3
Elmont silt loam, 3 to 8 percent	56	62	32	3.0	4.7
Eudora silt loam	86	90	48	5.0	7.8
Geary silt loam, 1 to 4 percent slopes	68	72	40	3.8	6.0
Geary silt loam, 4 to 8 percent slopes	60	64	36	3.6	5.2
Haynie very fine sandy loam	86	90	48	5.0	7.8
Irwin silty clay loam, 4 to 8 percent slopes	42	50	30	2.8	4.4
Irwin silty clay loam, 4 to 8 percent slopes, eroded	34	42	24	2.4	3.0
Ivan silty clay loam, 1 to 3 percent slopes	66	72	36	4.2	6.3
Ivan and Kennebec silt loams	70	76	40	4.8	7.0
Kahola silt loam	84	90	48	5.0	7.8
Kenesaw silt loam, 2 to 6 percent slopes	68	72	38	3.6	5.8
Kenesaw silt loam, 6 to 10 percent slopes	60	64	34	3.2	5.0
Mayberry clay loam, 2 to 6 percent slopes	60	68	36	3.4	5.2
Mayberry clay loam, 2 to 6 percent slopes, eroded	50	58	30	3.0	4.2
Muir silt loam	84	90	50	5.0	8.0
Reading silt loam, 0 to 1 percent slopes	82	88	50	5.0	7.9
Reading silt loam, 1 to 3 percent slopes	74	80	44	4.6	7.0
Smolan silt loam, 1 to 4 percent slopes	66	72	40	3.8	6.0
Smolan silt loam, 4 to 8 percent slopes	58	64	36	3.4	5.2
Smolan silty clay loam, 4 to 8 percent slopes, eroded	50	56	30	3.0	4.2
Sutphen silty clay	52	60	32	3.2	5.0
Tully silty clay loam, 1 to 4 percent slopes	64	72	42	4.0	6.2
Tully silty clay loam, 1 to 4 percent slopes, eroded	56	64	38	3.4	5.2
Tully silty clay loam, 4 to 8 percent slopes	58	66	38	3.6	5.5
Tully silty clay loam, 4 to 8 percent slopes, eroded	50	58	32	3.0	4.4
Wymore silty clay loam, 0 to 1 percent slopes	68	76	42	3.8	6.4
Wymore silty clay loam, 1 to 4 percent slopes	62	70	40	3.8	6.0
Wymore silty clay loam, 1 to 4 percent slopes, eroded	54	62	34	3.2	5.0
Wymore silty clay loam, 4 to 8 percent slopes	56	64	36	3.4	5.2
Wymore silty clay loam, 4 to 8 percent slopes, eroded	48	56	30	3.0	4.1

[1] Animal-unit-month is a term used to express the carrying capacity of pasture. It is the number of animal units per acre a pasture can carry each month without injury to the sod. An acre of pasture that provides 1 month of grazing for one cow, one horse, seven sheep, or five hogs has a carrying capacity of 1 animal-unit-month.

choosing a cropping system that keeps the soil in good condition.

Rangeland [4]

Rangeland makes up approximately 50 percent of the total survey area. The largest areas of range are in the eastern and southern parts of Riley County. Smaller areas are scattered throughout the rest of the county. Much of the range is on soils that are too rocky or too cherty for cultivation. Most of it, except for the Fort Riley Military Reservation, is used for steer or cow-calf operations. Only a small acreage is used for other kinds of livestock. A limited acreage of native grass is used for hay. Bromegrass, wheat, and crop residues provide additional areas for grazing.

Range sites and condition classes

Range is land on which the natural potential plant community is principally native grass, grasslike plants, forbs, and shrubs that are valuable for grazing use. The quality of the potential plant community on rangeland primarily depends on soil, topography, and climate. For management purposes, rangeland is grouped into range sites.

A *range site* is rangeland that differs from other rangeland in its capacity to produce native plants. A range site differs from other range sites if the yields are significantly different or if the kinds or proportions of plants are significantly different. These differences are great enough to require some difference in management.

Every range site has the potential capacity to support a distinct plant community. This distinct combination of plants is known as the original or *climax vegetation.* Climax vegetation generally is the most productive combination of range plants that will grow on a site.

Four range condition classes are used to indicate the degree to which the climax vegetation has been changed by grazing or other causes. The classes show the present condition of the native plants on a range site in relation to the native plants that potentially can be grown there. A range is in *excellent* condition if 76 to 100 percent of the present vegetation is the same kind that originally grew on it. It is in *good* condition if the percentage is between 51 and 75, in *fair* condition if the percentage is between 26 and 50, and in *poor* condition if the percentage is less than 25.

All range plants are placed into one of three groups, *decreasers*, *increasers*, or *invaders*. A *decreaser* is a plant that decreases or is replaced by other plants under excessive grazing. Decreasers generally are the most palatable plants and are grazed in preference to other species. An *increaser* is a less palatable or lower growing plant that is grazed less intensively. It will increase and replace the decreasers under excessive grazing. Decreasers and increasers make up the climax vegetation, but the decreasers are dominant. If overgrazing continues, decreasers are eliminated and undesirable, weed-type invaders are established. An *invader* is a plant that moves in from surrounding areas as the more desirable plants are grazed out.

[4] By LAWRENCE N. NIEMAN, range conservationist, Soil Conservation Service.

The key management practice on all rangeland is properly controlled grazing. In this geographic area, generally about one-half (by weight) of the forage produced by the principal decreasers can be safely removed by grazing during the growing season. Removing greater amounts of forage brings about detrimental changes in the plant community and reduces the future yield of forage.

Descriptions of range sites

In this section the range sites in Riley County are described, the composition of the climax vegetation on each site is given, and the principal invaders are listed. The potential yield of forage in favorable years and in unfavorable years is given by air-dry weight. A favorable year is one in which the total rainfall is normal or above. An unfavorable year is one in which the total rainfall is below normal.

The names of the soils in any given site can be found by referring to the "Guide to Mapping Units" at the back of this survey. Some mapping units that are a complex of soils have been assigned to two range sites.

BREAKS RANGE SITE

Only Stony steep land is in this range site. This mapping unit has slopes of 30 to 50 percent. It consists of shallow and moderately deep, medium-textured to fine-textured soils that have rock fragments on the soil surface and throughout the profile. In most places the rock is broken enough that it does not prevent deep rooting of native vegetation. Runoff is very rapid, and the soils are excessively drained.

In the climax plant community, forb and shrub decreasers produce as much as 25 percent of the total yield. Decreaser grasses produce most of the rest. Woody increasers and invaders spread rapidly if the site is overgrazed. Under continued overuse, brush and weedy annuals become dominant.

Common decreasers on this site are little bluestem, big bluestem, indiangrass, switchgrass, perennial sunflower, prairie-clover, and Jersey-tea ceanothus. Common increasers are sideoats grama, tall dropseed, hairy grama, western ragweed, smooth sumac, sedges, and aromatic sumac. Common invaders are broomweed, redcedar, annual three-awn, and buckbrush.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 4,000 pounds per acre. The total yield ranges from about 5,000 pounds per acre in favorable years to 3,000 pounds in unfavorable years.

Aerial spraying is beneficial on this site where brush has invaded. Proper grazing use and controlled burning prevent repeated encroachment of brush.

CLAY LOWLAND RANGE SITE

Sutphen silty clay is the only soil in this range site. This soil is on nearly level bottom lands, where it receives additional water as runoff from adjacent slopes. It is deep and is moderately well drained to somewhat poorly drained. Permeability is very slow. The soil is fine textured throughout. When dry, it is extremely hard and has large, deep cracks.

Prairie cordgrass makes up a major part of the climax plant community on this site. The decreasers, such as

big bluestem, indiangrass, and switchgrass, along with prairie cordgrass, produce more than 80 percent of the total forage in the climax community. Increasers account for the rest. Under prolonged overgrazing, annual grasses and weed trees are dominant on this site.

Common decreasers are prairie cordgrass, big bluestem, indiangrass, switchgrass, eastern gamagrass, Maximilian sunflower, and wholeleaf rosinweed. Common increasers are sedge, tall dropseed, western wheatgrass, Baldwin ironweed, blue grama, western ragweed, woolly verbana, buckrush, and indigobush. Common invaders are Kentucky bluegrass, barnyard grass, annual three-awn, annual bromes, and redcedar.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 7,500 pounds per acre. The total yield ranges from about 10,000 pounds per acre in favorable years to 5,000 pounds in unfavorable years.

CLAYPAN RANGE SITE

This site consists of deep, gently sloping and sloping soils on uplands. These soils have a medium-textured and moderately fine textured surface layer that, in most places, is less than 7 inches thick over a fine-textured subsoil. The soils are moderately well drained to well drained, and they have slow to very slow permeability. They are droughty because their subsoil restricts water moving into the soil and releases water slowly to plants during periods of stress.

In the climax plant community, decreasers produce as much as 60 percent of the total forage and increasers account for the rest. Sideoats grama, little bluestem, switchgrass, blue grama, and tall dropseed generally make up most of the production. Under continued overuse, the plant community is mostly annual grasses and annual forbs. Annual three-awn becomes dominant where the site is in poor condition.

Common decreasers on this site are big bluestem, little bluestem, switchgrass, sideoats grama, prairie-clover, leadplant amorpha, and heath aster. The common increasers are buffalograss, tall dropseed, blue grama, western wheatgrass, manyflower scurf-pea, sedges, and western ragweed. The common invaders are annual bromes, annual three-awn, broomweed, and annual ragweed.

If this site is in excellent condition, the average annual yield of air-dry herbage averages about 2,500 pounds per acre. The total yield ranges from about 3,500 pounds per acre in favorable years to 1,500 pounds in unfavorable years.

The plants on the Claypan range site respond slowly to improvement practices. Under grazing, this site seldom is in excellent condition. Because it is so accessible, livestock tend to keep it overgrazed. Many acres of former cropland, or "go-back" land, are in this site. Fencing and reseeding these "go-back" areas improve their condition.

CLAY UPLAND RANGE SITE

This site consists of nearly level to sloping soils that have a moderately fine textured surface layer and a moderately fine textured to fine textured subsoil. These soils are deep and are moderately well drained to well drained. Their permeability is slow to very slow. The subsoil is blocky, and it restricts the movement of water and air. Because the level of water retention is high, these soils do not release an adequate amount of water to plants during periods of stress.

Decreaser grasses produce 75 percent or more of the total forage in the climax plant community. Increasers, such as tall dropseed and side-oats grama, produce most of the rest. Annual grasses, tall dropseed, and buckbrush become dominant if the site is overgrazed for a long period of time.

Common decreasers on this site are big bluestem, little bluestem, indiangrass, switchgrass, prairie-clover, and leadplant amorpha. Common increasers are tall dropseed, sideoats grama, blue grama, western wheatgrass, manyflower scurf-pea, and western ragweed. Common invaders are annual grasses, broomweed, Kentucky bluegrass, buckbrush, windmillgrass, ironweed, and woolly verbena.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 4,500 pounds per acre. The total yield ranges from about 7,000 pounds per acre in favorable years to 2,000 pounds in unfavorable years. When moisture conditions are favorable throughout the growing season, this is the most productive upland site in Riley County. In dry years, however, the forage yield is low. The yield fluctuates considerably from year to year.

Careful management of grazing is needed to maintain maximum productivity of the better forage plants. To prevent overgrazing, the stocking rate must be adjusted to match changes in forage production. Careful management is more important on this range site than on other sites.

The plants on this site respond readily to improvement practices. Proper location of ponds for uniform distribution of grazing is a problem in some areas where there are no suitable pond sites. Placing wells, salt, or supplements in lightly grazed areas is especially important where this problem is encountered.

LIMY UPLAND RANGE SITE

This site consists of moderately deep, sloping to moderately steep soils on uplands. These soils have a moderately fine textured surface layer and subsoil, and they are calcareous within 10 inches of the surface. They are moderately well drained to well drained, and their permeability is moderately slow.

Shrub and forb decreasers produce as much as 25 percent of the total yield in the climax plant community. Decreaser grasses, such as big bluestem, little bluestem, and indiangrass, make up 60 percent or more of the total yield. If the site is overgrazed, increasers rapidly replace the decreasers. Under continued overuse, the plant cover deteriorates to annual broomweed, annual bromes, annual three-awn, and brush.

Common decreasers on this site are little bluestem, big bluestem, indiangrass, switchgrass, blacksamson, pitcher sage, Jersey-tea ceanothus, leadplant, and prairie-clovers. Common increasers are sideoats grama, hairy grama, Missouri goldenrod, stiff goldenrod, tall dropseed, smooth sumac, and aromatic sumac. Common invaders are annual bromes, annual three-awn, broomweed, buckbrush, and redcedar.

If this site is in excellent condition, the total annual yield averages about 3,500 pounds of air-dry herbage per acre. The total yield ranges from about 4,500 pounds per acre in favorable years to 2,500 pounds in unfavorable years.

Smooth sumac, aromatic sumac, and buckbrush are a concern where this site has been overgrazed. Resting the range and applying chemicals for controlling brush are measures that improve these overgrazed areas. The amount of brush can be kept from becoming excessive by proper grazing use and occasional controlled burning. Even under proper management, brush generally is present in small amounts on this site.

LOAMY LOWLAND RANGE SITE

This site consists of deep soils on lowlands that are nearly level in most places. These soils receive additional water from flooding and as runoff from adjacent slopes. They have a medium-textured to moderately fine textured surface layer and a medium-textured to fine-textured subsoil. They are well drained to somewhat poorly drained, and their permeability is moderate to slow. The relationship of air and water to plants is excellent in these soils.

Decreasers make up 90 percent or more of the climax plant community. Side-oats grama, tall dropseed, forbs, and brush are the main increasers if the site is overgrazed. Weed trees, brush, annual grasses, and annual forbs become dominant under continued overgrazing.

Common decreasers on this site are big bluestem, indiangrass, switchgrass, eastern gamagrass, Canada wildrye, compassplant, wholeleaf rosinweed, and perennial sunflower. Common increasers are sideoats grama, tall dropseed, western wheatgrass, blue grama, sedges, Baldwin ironweed, buckbrush, woolly verbena, meadow dropseed, tall dropseed, heath aster, and indigobush. Common invaders are barnyard grass, Kentucky bluegrass, sandbur, musk thistle, annual three-awn, and redcedar.

This site produces the highest average yield of any site in Riley County where it is in good or excellent condition. If the site is in excellent condition, the total annual yield of air-dry herbage averages about 8,000 pounds per acre. The total yield ranges from about 6,000 pounds per acre in unfavorable years to 10,000 pounds in favorable years.

This range site is difficult to maintain in excellent condition. As cattle travel to and from watering locations, they concentrate on this site and generally keep it overgrazed. Locating salt or other supplements in lightly grazed upland areas helps in drawing cattle from this site. Where overgrazing cannot be prevented, brush control may be needed periodically to keep the condition of the range reasonably high.

LOAMY UPLAND RANGE SITE

This site consists of nearly level to moderately steep, moderately deep to deep soils on uplands (fig. 23). These soils have a medium-textured to moderately fine textured surface layer and a medium-textured to fine-textured subsoil. Fragments of rock or chert are on the surface and throughout the profile of some of the soils. Soils in this site are well drained to moderately well drained. Permeability is moderate to slow. The relationship of water and air to plants is good in these soils.

In the climax plant community, decreasers produce 85 percent or more of the total forage. Big and little bluestems are dominant. Increasers account for about 15 percent of the total forage. Sideoats grama, tall dropseed, blue grama, and western ragweed are the main increasers that replace decreasers if the site is overgrazed. Under prolonged overgrazing, annual three-awn, annual

Figure 23.—**Cattle grazing on Loamy Upland range site. The soil is Smolan silt loam, 1 to 4 percent slopes.**

bromes, buckbrush, and other invaders make up a large part of the plant community.

Common decreasers on this site are little bluestem, big bluestem, indiangrass, switchgrass, prairie-clover, leadplant amorpha, Jersey-tea ceanothus, and pitcher sage. Common increasers are sideoats grama, blue grama, tall dropseed, western ragweed, heath aster, Missouri goldenrod, stiff goldenrod, and smooth sumac. Common invaders are annual three-awn, annual bromes, buckbrush, annual broomweed, and Kentucky bluegrass.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 5,000 pounds per acre. The total yield ranges from about 6,500 pounds per acre in favorable years to 3,500 pounds in unfavorable years. The average yield on this site is close to the average yield on the Clay Upland range site, but fluctuations in yield are not so great on this site. Controlled burning is needed occasionally to control brush and to help obtain a uniform distribution of grazing. The plants on this site respond quickly to improvement measures, especially in favorable years.

SANDS RANGE SITE

This site consists of nearly level to gently undulating soils on the flood plains of the Kansas and Republican Rivers. These soils are coarse textured in their surface layer and subsoil. The intake of water is rapid, and permeability of the subsoil is very rapid. These soils are deep, but they are excessively drained. The available moisture capacity is low.

Decreasers produce as much as 80 percent of the total forage in the climax plant community. Increasers account for the rest.

Common decreasers on this site are big bluestem, indiangrass, switchgrass, eastern gamagrass, Canada wildrye, compassplant, wholeleaf rosinweed, and perennial sunflower. Increasers are sideoats grama, western wheatgrass, blue grama, sedges, Baldwin ironweed, buckbrush, woolly verbena, meadow dropseed, tall dropseed, heath aster, and indigobush. Common invaders are barnyard grass, Kentucky bluegrass, sandbur, and muskthistle.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 4,000 pounds per acre. The total yield ranges from about 5,000 pounds per acre in favorable years to about 3,000 pounds in unfavorable years.

The soils in this site are highly susceptible to soil blowing if the plant cover is removed by overgrazing.

SANDY LOWLAND RANGE SITE

This site consists of deep, nearly level soils on flood plains of the Kansas and Republican Rivers. These soils are moderately coarse textured in their surface layer and subsoil. They are well drained to moderately well drained. Permeability is moderate to rapid.

Decreasers produce as much as 90 percent of the total forage in the climax plant community. Increasers account for the rest.

Common decreasers on this site are sand bluestem, big bluestem, little bluestem, switchgrass, indiangrass, and sand lovegrass. Common increasers are blue grama, sideoats grama, western wheatgrass, sand dropseed, small soapweed, and sand paspalum. Common invaders are annual brome, annual three-awn, cocklebur, and sandbur.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 6,500 pounds per acre. The total yield ranges from about 8,000 pounds per acre in favorable years to 5,000 pounds in unfavorable years.

The soils in this range site are highly susceptible to soil blowing if the plant cover is removed by excessive grazing.

SHALLOW LIMY RANGE SITE

This site occurs as narrow bands on uplands in association with the Limy Upland range site. The soils are sloping, shallow, moderately fine textured, and somewhat excessively drained. Permeability is moderate. Limestone bedrock limits the amount of water available for plant use, and it inhibits the normal development of roots. As a result, this is a low-producing site.

Little bluestem, side-oats grama, forbs, and other decreasers generally produce 60 percent or more of the total yield in the climax plant community. Increasers produce most of the rest. Blue grama, hairy grama, and buffalograss replace the more desirable plants if the site is overgrazed. Annual bromes, annual three-awn, and annual broomweed make up a large part of the plant community under continued overgrazing.

Common decreasers on this site are big bluestem, little bluestem, switchgrass, prairie-clovers, and blacksamson. Common increasers are sideoats grama, blue grama, hairy grama, buffalograss, smooth sumac, willowleaf sunflower, and aromatic sumac. Common invaders are broomweed, annual bromes, annual three-awn, and silver bluestem.

If this site is in excellent condition, the total annual yield of air-dry herbage averages about 2,500 pounds per acre. The total yield ranges from about 1,500 pounds per acre in unfavorable years to 3,500 pounds in favorable years.

Use of Soils for Woodland and Windbreaks [5]

In this section the soils of the survey area are discussed according to their suitability as woodland and for farmstead windbreaks. The soils are placed in four woodland suitability groups, the soil-related factors are rated, and the trees suited to each group are listed. Trees and shrubs suited to farmstead windbreaks are listed for eight broad groups of soils.

Native woodland

In the survey area there are about 30,000 acres of woodland. It lies mostly in narrow bands along the streams and on some of the steep slopes bordering the stream valleys. Many of the stands can produce good sawtimber if they are properly managed. Woodland should be protected from fire and grazing and cleared of cull trees and wolf trees.

Potential soil productivity for wood crops is expressed as the site index, which is the height attained by the average dominant and codominant trees at the age of 50 years. The site index reflects the rate of tree growth or potential productivity for suitable tree species. A woodland suitability group is made up of soils that pro-

[5] By F. D. Abbott, State resource conservationist, Soil Conservation Service.

duce similar kinds of wood crops, that need similar management to produce these crops, and that have about the same potential productivity.

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

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

The ratings for equipment limitations are based on the degree that soils and topographic features restrict or prohibit the use of equipment normally employed in tending a crop of trees. The limitation is *slight* if there is little or no restriction of the type of equipment that can be used, or the time of year that equipment can be used. It is *moderate* if the use of equipment is seasonally limited, or if modified equipment or methods of harvesting are needed. The limitation is *severe* if special equipment is needed or if the use of such equipment is severely restricted by one or more unfavorable soil characteristics.

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

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

The woodland suitability groups in Riley County are discussed in the following paragraphs. The names of land types and soil series represented in a woodland suitability group are named in the description of the group. This does not mean that all the soils of a given series appear in that group. To find the names of all the soils in any given woodland suitability group, refer to the "Guide to Mapping Units" at the back of this survey. The absence of a woodland suitability group designation indicates that the soil is generally not suited to wood crops.

WOODLAND SUITABILITY GROUP 1

This group consists of Alluvial land and Ivan and Kennebec silt loams. These soils are deep, nearly level, and well drained to moderately well drained. Their permeability is moderate to moderately slow. Soils of this group generally are loamy throughout, but Alluvial land has a clayey subsoil in places. These soils are on the flood plains of creeks and other small streams. They are subject to flooding, but floods are of short duration.

Soils of this group are good producers. The site index for the mixed hardwoods suited to these soils ranges from 50 to 80 for different species. The rating is 65 to 75 for black walnut, 65 to 75 for hackberry, 65 to 75 for green ash, 50 to 60 for bur oak, and 75 to 85 for soft maple. Annually, these soils can be expected to produce 170 to 230 board feet per acre of black walnut, hackberry, and green ash; 220 to 280 board feet of soft maple; and 100 to 140 board feet of bur oak.

Seedling mortality resulting from spring flooding is moderate, and the loss of seedlings from drought is slight. Plant competition is severe. Vines and weed trees hinder growth of desirable species, and competition from this source needs to be reduced.

Equipment limitations are slight. Only flooding prevents operation of logging and other equipment. The windthrow hazard is slight; no special precautions are necessary. The erosion hazard is slight. Clean cutting in or near old or existing stream channels should be avoided to prevent bank erosion.

Black walnut, bur oak, soft maple, green ash, hackberry, and sycamore are species that are suited to this group of soils.

WOODLAND SUITABILITY GROUP 2

Sutphen silty clay is the only soil in this group. It is deep, nearly level, and somewhat poorly drained to moderately well drained. Its permeability is very slow. This soil is on stream terraces.

The soil in this group produces a fair growth of plants. The native vegetation is open grassland in most places. The site index for the mixed hardwoods that grow on this soil ranges from about 50 to 60 for different species. Annually, this soil can be expected to produce 100 to 140 board feet per acre of green ash, soft maple, or American elm.

Seedling mortality resulting from wetness is moderate, and the loss of trees from drought in dry summers is common. Plant competition is severe. Desirable species must compete with grass, weed trees, and vines.

Equipment limitations are severe. Operating equipment causes compaction of the soil and injury to the roots, except for periods during the dry months. Because the windthrow hazard is severe, the stands should be opened slowly and single trees should not be left. The erosion hazard is slight.

Soft maple, green ash, and American elm are species that are suited to the soil in this group.

WOODLAND SUITABILITY GROUP 3

This group consists of soils of the Chase, Eudora, Haynie, Ivan, Kahola, Muir, and Reading series. These soils are deep, nearly level, and well drained to somewhat poorly drained. Their permeability is moderate to slow. They are loamy throughout, except for the Chase soils, which have a clayey subsoil. Soils of this group are on bottom lands that are rarely flooded.

These soils are good producers. The site index ranges from about 65 to 75 for bur oak, green ash, and hackberry. The rating for black walnut is 60 to 75. Annually, these soils can be expected to produce from 170 to 230

board feet per acre of black walnut, green ash, and hackberry. Bur oak produces from 100 to 140 board feet.

Seedling mortality is slight. Soil conditions are favorable for good survival and growth of seedlings. Plant competition is moderate. Some treatment is needed to remove competition of vines and wood trees.

Equipment limitations are slight. The windthrow hazard and the erosion hazard are slight.

Black walnut, bur oak, green ash, and hackberry are species that are suited to the soils in this group.

WOODLAND SUITABILITY GROUP 4

This group consists of soils of the Carr and Sarpy series. These soils are deep. Their permeability is moderate to very rapid. Carr soils are loamy throughout and are well drained to moderately well drained. Sarpy soils are sandy throughout and are excessively drained. There is very little surface runoff from these soils. The soils are on bottom lands and are subject to flooding.

The site index ranges from about 65 to 75 for cottonwood.

Seedling mortality and plant competition are slight. Soil conditions permit seedlings to establish themselves easily and to grow well. No special treatment is required for regeneration and growth.

Equipment limitations are slight. The use of equipment is limited only by flooding. Because the windthrow hazard is moderate, caution should be used in opening up dense stands, and single trees should not be left. Deposition is common, but only the major floods cause damage. The erosion hazard is slight.

Cottonwood and sycamore are species that are suited to the soils in this group.

Farmstead windbreaks

Farmsteads that are exposed to cold winds in winter and to hot winds in summer need the protection of windbreaks. Many feedlots in Riley County also need the protection of windbreaks. Trees and shrubs for windbreaks should be selected according to their suitability for the soils. All of the soils in Riley County will grow trees suitable for windbreaks if the proper species are selected.

The soils are divided into eight windbreak suitability groups. The names of land types and soil series represented in each windbreak suitability group are named in the description of that group. This does not mean that all the soils of a given series appear in that group. To find the names of all soils in any given windbreak suitability group, refer to the "Guide to Mapping Units" at the back of this survey.

The species suited to the soils in each windbreak suitability group are listed in the following pages. Siberian elm, Osage-orange, and multiflora rose may volunteer in fields, ditches, and other places where they are not wanted. This should be considered when a windbreak is planned.

WINDBREAK SUITABILITY GROUP A

This group consists of soils of the Chase, Eudora, Haynie, Ivan, Kahola, Kennebec, Muir, and Reading series. Also in the group are Alluvial land and the Alluvial land part of Breaks-Alluvial land complex. These soils are nearly level to gently sloping and occur on bottom lands, alluvial fans, and foot slopes. Alluvial land and the Ivan and Kennebec soils are subject to frequent flooding.

Soils of this group have moderate to slow permeability. Root penetration is good, and the soils are suited to most trees grown locally. Trees and shrubs suitable for planting are:

Conifers: Austrian pine, ponderosa pine, Scotch pine, and eastern redcedar.
Tall broadleaf trees that are fast growers: Siberian elm, cottonwood, silver maple, and sycamore.
Tall broadleaf trees that are slow to moderate growers: Black walnut, bur oak, green ash, hackberry, honeylocust, pecan, and pin oak.
Intermediate broadleaf trees: Osage-orange, Russian mulberry, and Russian-olive.
Shrubs: Bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP B

Sutphen silty clay is the only soil in this group. This soil is nearly level and occurs on stream terraces. It is deep and moderately well drained to somewhat poorly drained.

This soil has very slow permeability. It dries slowly after rain and cracks during dry periods. Trees and shrubs suitable for planting are:

Conifers: Austrian pine, eastern redcedar, and ponderosa pine.
Tall broadleaf trees that are fast growers: Cottonwood, silver maple, and sycamore.
Tall broadleaf trees that are slow to moderate growers: Bur oak, green ash, hackberry, honeylocust, and pin oak.
Intermediate broadleaf trees: Osage-orange, Russian mulberry, and Russion-olive.
Shrubs: Bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP C

This group consists of soils of the Benfield, Elmont, Geary, Irwin, Kenesaw, Mayberry, Smolan, Tully, and Wymore series. These soils are moderately deep to deep and are nearly level to moderately steep. They occur on high terraces, foot slopes, and uplands. They are well drained to moderately well drained.

Soils of this group have moderate to very slow permeability. Root penetration is good, and moisture available for plant growth is fair to good. Trees and shrubs suitable for planting are:

Conifers: Austrian pine, ponderosa pine, Scotch pine, and eastern redcedar.
Tall broadleaf trees that are fast growers: Siberian elm, cottonwood, silver maple, and sycamore.
Tall broadleaf trees that are slow to moderate growers: Bur oak, green ash, hackberry, honeylocust, and pin oak.
Intermediate broadleaf trees: Osage-orange, Russian mulberry, and Russian-olive.
Shrubs: Fragrant sumac, gray dogwood, bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP D

This group consists of soils of the Clime series. These soils are moderately deep and occur on uplands. They are moderately well drained to well drained and are calcareous.

These soils have moderately slow permeability. Root penetration and the amount of moisture available for plant growth are only fair. Trees and shrubs suitable for planting are:

Conifers: Eastern redcedar and Austrian pine.
Tall broadleaf trees that are slow to moderate growers: Bur oak, honeylocust, green ash, and hackberry.
Intermediate broadleaf trees: Osage-orange, Russian mulberry, and Russian-olive.
Shrubs: Fragrant sumac, gray dogwood, bush-honeysuckle, lilac, multiflora rose, and American plum.

WINDBREAK SUITABILITY GROUP E

This group consists of soils of the Dwight, Irwin, Mayberry, Smolan, Tully, and Wymore series. Also in this group is the Breaks part of Breaks-Alluvial land complex. These soils are well drained to moderately well drained and occur on high terraces, foot slopes, and uplands. They are deep, but they have a thin surface layer.

Soils of this group have slow to very slow permeability, and they are droughty in dry periods. Root penetration is fair to poor. Trees and shrubs suitable for planting are:

Conifers: Eastern redcedar.
Tall broadleaf trees that are slow to moderate growers: Pin oak.
Intermediate broadleaf trees: Osage-orange.
Shrubs: Fragrant sumac.

WINDBREAK SUITABILITY GROUP F

This group consists of Stony steep land and soils of the Florence series. These soils are moderately steep or steep and occur on uplands. They are well drained to excessively drained and are shallow to moderately deep. They have fragments of chert or limestone in one or more layers.

Soils of this group have moderately slow to slow permeability. Root penetration is fair to good, and the amount of moisture available for plant growth is fair to good. Trees and shrubs suitable for planting are:

Conifers: Eastern redcedar, Austrian pine, and Scotch pine.
Tall broadleaf trees that are slow to moderate growers: Bur oak and honeylocust.
Intermediate broadleaf trees: Osage-orange.
Shrubs: Fragrant sumac, gray dogwood, and American plum.

WINDBREAK SUITABILITY GROUP G

This group consists of soils of the Sogn series. Also in the group are areas of limestone outcrops. These soils are sloping and occur on uplands. They are shallow and somewhat excessively drained. They have very low available moisture capacity.

Soils of this group have moderate permeability. Root penetration is shallow in most places, and the amount of moisture available for plant growth generally is small. Trees and shrubs suitable for planting are:

Conifers: Eastern redcedar.
Intermediate broadleaf trees: Osage-orange.
Shrubs: Fragrant sumac and gray dogwood.

WINDBREAK SUITABILITY GROUP H

This group consists of soils of the Carr and Sarpy series. These soils are nearly level to gently undulating and occur on bottom lands. They are deep and moderately well drained to excessively drained. They are subject to some flooding.

Soils of this group have moderate to very rapid permeability. Root penetration is good. Trees and shrubs suitable for planting are:

Conifers: Austrian pine, eastern redcedar, and Rocky Mountain juniper.
Tall broadleaf trees that are fast growers: Siberian elm and cottonwood.
Tall broadleaf trees that are slow to moderate growers: Bur oak, green ash, and honeylocust.
Intermediate broadleaf trees: Osage-orange, Russian mulberry, and Russian-olive.
Shrubs: Fragrant sumac, lilac, and American plum.

Fish and Wildlife Management [6]

The survey area has several major factors that affect fish and wildlife resources. Tuttle Creek Reservoir, a lake covering an area of 15,800 acres, forms approximately two-thirds of the eastern boundary between Riley and Pottawatomie Counties. Part of the area around the reservoir is managed by the Forestry, Fish and Game Commission as a public hunting area and wildlife refuge.

Fort Riley, a U.S. Army reservation that covers approximately 92,000 acres within the survey area, restricts hunting and fishing in a large land area. The Army manages some areas for fish and wildlife by keeping the wildlife population within limits established by State game laws and regulations.

WILDLIFE HABITAT. A convenient way of discussing wildlife in the county is by soil associations. The soil associations are described in the section "General Soil Map," and the location of each association is shown on the general soil map at the back of this soil survey. Table 3 rates the potential of each of the associations for producing food and cover for three main groups of wildlife (openland, woodland, and wetland), which are defined in the paragraphs that follow. The table also rates the potential of each association for producing needed habitat for fish.

Openland wildlife consists of birds and mammals that normally inhabit cropland, pasture, meadow, lawns, and areas overgrown with grasses, herbs, and shrubby growth. Examples of this kind of wildlife are quail, pheasant, meadowlark, field sparrow, redwinged blackbird, cottontail rabbit, red fox, and marmot.

Woodland wildlife consists of birds and mammals that normally inhabit wooded areas of hardwood trees and shrubs, coniferous trees and shrubs, or mixtures of such

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

TABLE 3.—*Potential of the soil associations for providing the habitat required by three main groups of wildlife*

[Absence of an entry in a column indicates that potential of soil association is not rated]

Soil association	Kind of wildlife	Potential for producing—			
		Woody cover	Herbaceous cover	Aquatic habitat	Food
Wymore-Irwin.	Openland	Good	Excellent	Excellent	Excellent.
	Woodland	Good	Excellent	Excellent	Good.
	Wetland	Good	Excellent	Excellent	Excellent.
	Fish			Excellent	Excellent.
Smolan-Geary.	Openland	Good	Excellent	Excellent	Excellent.
	Woodland	Good	Excellent	Excellent	Good.
	Wetland	Good	Excellent	Excellent	Excellent.
	Fish			Excellent	Excellent.
Eudora-Haynie-Sarpy.	Openland	Excellent	Excellent	Excellent	Excellent.
	Woodland	Excellent	Excellent	Excellent	Excellent.
	Wetland	Excellent	Excellent	Excellent	Excellent.
	Fish			Excellent	Excellent.
Reading-Kennebec-Ivan.	Openland	Excellent	Excellent	Excellent	Excellent.
	Woodland	Excellent	Excellent	Excellent	Excellent.
	Wetland	Excellent	Excellent	Excellent	Excellent.
	Fish			Excellent	Excellent.
Benfield-Florence.	Openland	Excellent	Excellent	Good	Good.
	Woodland	Good	Excellent	Good	Good.
	Wetland	Good	Excellent	Fair	Fair.
	Fish			Fair	Good.
Clime-Sogn.	Openland	Good	Good	Fair	Fair.
	Woodland	Poor	Fair	Fair	Fair.
	Wetland	Poor	Poor	Poor	Fair.
	Fish			Poor	Poor.

plants. Examples of this kind of wildlife are thrushes, cardinals, fox squirrel, red fox, white-tailed deer, mule deer, raccoon, and turkey.

Wetland wildlife consists of birds and mammals that normally inhabit wet areas, such as ponds, streams, ditches, marshes, and swamps. Examples of this kind of wildlife are wood duck, rail, heron, shorebirds, mink, muskrat, beaver, and mallard and pintail ducks.

KINDS OF WILDLIFE. Many kinds of wildlife are in Riley County. Among the most important are bobwhite quail, ring-necked pheasant, prairie chicken, various kinds of wetland wildlife, white-tailed deer, and mule deer.

Bobwhite quail is one of the most popular openland game birds in the county. The largest populations are on the Reading-Kennebec-Ivan and Eudora-Haynie-Sarpy associations. Wooded areas and cropland used for corn, grain sorghum, wheat, and alfalfa provide ideal habitat for quail. All associations support a good population of quail.

Pheasant live in fair numbers on the Wymore-Irwin and Smolan-Geary associations. Cropland that is interspersed with brush areas and shelterbelts provides year-round habitat for pheasants.

Prairie chickens are in areas of grassland on the Clime-Sogn and Benfield-Florence associations. The shallow soils that are not suited to cultivation provide extensive areas of native grass. These areas are essential for producing and maintaining a good population of this native game bird.

Wetland wildlife, such as waterfowl, beaver, muskrats, and mink, are most common on the Eudora-Haynie-Sarpy and Reading-Kennebec-Ivan associations. Numerous farm ponds on other soil associations provide additional habitat for wetland wildlife.

Many white-tailed deer, and a smaller number of mule deer, live in the county. These deer are mainly on the Eudora-Haynie-Sarpy and Reading-Kennebec-Ivan associations. Both associations also provide desirable habitat for cottontail rabbit and for song and insectivorous birds, such as thrasher, cardinal, woodpecker, flycatcher, warbler, oriole, and robin.

Fishing is good to excellent in the many farm ponds, reservoirs, and streams throughout the county. Bass, bluegill, channel catfish, yellow catfish, bullhead, and crappie are the primary game fish. These fish, and also northern pike and walleye, can be caught in Tuttle Creek Reservoir.

Information and assistance in planning and developing wildlife habitat can be obtained from the Soil Conservation Service, the Kansas Forestry, Fish and Game Commission, the Bureau of Sport Fisheries and Wildlife, and the Cooperative Exension Service.

Use of Soils for Recreation [7]

Recreation opportunities in the survey area were expanded by the development of Tuttle Creek Reservoir

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

and its water-related activities. Areas for intensive recreation use include those developed by the Park and Resources Authority and the U.S. Army Corps of Engineers. The Forestry, Fish and Game Commission administers approximately 4,000 acres of land for use by the public as shooting areas, and it manages the water area for fish.

Fort Riley provides many kinds of recreational activities for military personnel. An excellent grass golf course is one example. Excellent opportunities, both public and private, exist within the county for further development of recreational areas.

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 4 the soils of Riley County are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails.

In table 4 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intensive maintenance, or a combination of these, is required.

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

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

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

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

TABLE 4.—*Limitations of the soils for recreational uses*

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

Soil series and map symbols	Degree and kind of limitation of soils used for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Alluvial land: Ad	Severe: subject to frequent flooding.	Severe: subject to frequent flooding.	Severe: subject to frequent flooding.	Severe: subject to frequent flooding.
*Benfield: Bf. For Florence part, see Florence series.	Moderate: contains coarse fragments; sloping and moderately steep; severe where slopes are 15 percent or more.	Moderate: contains coarse fragments; sloping and moderately steep; severe where slopes are 15 percent or more.	Severe: sloping and moderately steep.	Moderate: moderately fine textured surface layer; contains coarse fragments.
Breaks-Alluvial land complex: Bk.	Severe: subject to frequent flooding; nearly level to moderately steep.	Moderate: subject to frequent flooding; nearly level to moderately steep; severe where slopes are 15 percent or more.	Severe: subject to frequent flooding; nearly level to moderately steep.	Moderate: subject to frequent flooding; nearly level to moderately steep; severe where slopes are 25 percent or more.
*Carr: Ca. For Sarpy part, see Sarpy series.	Severe: subject to some flooding.	Moderate: subject to some flooding.	Severe: subject to some flooding.	Slight.

TABLE 4.—*Limitations of the soils for recreational uses*—Continued

Soil series and map symbols	Degree and kind of limitation of soils used for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Chase: Ch	Moderate or severe: moderately fine textured surface layer; slow permeability; rarely subject to flooding.	Moderate: moderately fine textured surface layer.	Moderate: slow permeability; moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.
*Clime: Cs For Sogn part, see Sogn series.	Moderate: moderately slow permeability; moderately fine textured surface layer; sloping and moderately steep; severe where slopes are 15 percent or more.	Moderate: moderately fine textured surface layer; sloping and moderately steep; severe where slopes are 15 percent or more.	Severe: sloping and moderately steep.	Moderate: sloping and moderately steep; moderately fine textured surface layer.
*Dwight: Dr, Dw For Irwin part, see Irwin series.	Severe: very slow permeability.	Moderate: moderately well drained; moderately fine textured surface layer where eroded.	Severe: very slow permeability; moderately fine textured surface layer where eroded.	Moderate: moderately well drained; moderately fine textured surface layer where eroded.
*Elmont: Em, En For Clime part of En, see Clime series.	Moderate: moderately slow permeability; moderately steep in places.	Slight where slopes are less than 8 percent; moderate where slopes are 8 percent or more.	Moderate: moderately slow permeability; sloping and moderately steep; severe where slopes are 6 percent or more.	Slight.
Eudora: Eu	Slight	Slight	Slight	Slight.
Florence Mapped only in a complex with Benfield soils.	Moderate: moderately slow permeability; sloping and moderately steep; cherty silt loam surface layer; severe where slopes are 15 percent or more.	Moderate: sloping and moderately steep; severe where slopes are 15 percent or more.	Severe: sloping and moderately steep.	Moderate: cherty silt loam surface layer.
Geary: Ga, Ge	Slight	Slight	Moderate: gently sloping and sloping; severe where slopes are 6 percent or more.	Slight.
Haynie: Ha	Severe: subject to some flooding.	Moderate: subject to some flooding.	Moderate: subject to some flooding.	Slight.
Irwin: Ic, Id	Severe: very slow permeability.	Moderate: moderately fine textured surface layer.	Severe: very slow permeability; gently sloping and sloping.	Moderate: moderately fine textured surface layer.
*Ivan:				
Ie	Moderate: moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.
Iv For Kennebec part of Iv, see Kennebec series.	Severe: subject to flooding.	Moderate: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.
Kahola: Ka	Severe: subject to some flooding.	Moderate: subject to some flooding.	Moderate: subject to some flooding.	Slight.
Kenesaw: Ke, Kf	Slight where slopes are less than 8 percent; moderate where slopes are 8 percent or more.	Slight where slopes are less than 8 percent; moderate where slopes are 8 percent or more.	Moderate where slopes are less than 6 percent; severe where slopes are 6 percent or more.	Slight.

TABLE 4.—*Limitations of the soils for recreational uses*—Continued

Soil series and map symbols	Degree and kind of limitation of soils used for—			
	Camp areas	Picnic areas	Playgrounds	Paths and trails
Kennebec. Mapped only in an undifferentiated group with Ivan soils.	Severe: subject to flooding.	Moderate: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.
Mayberry: Ma, Mb	Moderate: slow permeability; moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.	Moderate: slow permeability; gently sloping and sloping; moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.
Muir: Mu	Slight	Slight	Slight	Slight.
Reading: Rd, Re	Moderate: moderately slow permeability.	Slight	Moderate: moderately slow permeability.	Slight.
Sarpy: Sa	Severe: subject to some flooding.	Moderate: coarse-textured surface layer; subject to some flooding.	Severe: subject to some flooding; coarse-textured surface layer; subject to blowing.	Moderate: coarse-textured surface layer.
Smolan: Sm, Sn	Moderate: slow permeability.	Slight	Moderate: slow permeability; gently sloping and sloping; severe where slopes are 6 percent or more.	Slight.
So	Moderate: slow permeability; moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.	Moderate: slow permeability; moderately fine textured surface layer; gently sloping and sloping; severe where slopes are 6 percent or more.	Moderate: moderately fine textured surface layer.
Sogn. Mapped only in a complex with Clime soils.	Severe: rocky	Severe: rocky	Severe: sloping; rocky	Severe: rocky.
Stony steep land: St	Severe: steep	Severe: steep	Severe: steep	Severe: steep.
Sutphen: Su	Severe: very slow permeability; fine textured surface layer.	Severe: fine-textured surface layer.	Severe: very slow permeability; fine-textured surface layer.	Severe: fine-textured surface layer.
Tully: Ts, Tt, Tu, Tv	Moderate: slow permeability; moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.	Moderate: slow permeability; moderately fine textured surface layer; gently sloping and sloping; severe where slopes are 6 percent or more.	Moderate: moderately fine textured surface layer.
Wymore: Wm, Wn, Wo, Wr, Ws.	Moderate: slow permeability; moderately fine textured surface layer.	Moderate: moderately fine textured surface layer.	Moderate: slow permeability; moderately fine textured surface layer; nearly level to sloping; severe where slopes are 6 percent or more.	Moderate: moderately fine textured surface layer.

Engineering Uses of Soils [8]

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

Among the properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

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

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

Most of the information in this section is presented in tables 5 and 6, which show, respectively, several estimated soil properties significant to engineering and interpretations for various engineering uses.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 5 and 6, and it can also be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables. The estimates generally are to depths of about 5 feet, and therefore interpretations normally do not apply to greater depths. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that is not known to all engineers. The Glossary defines many of these terms used in soil science.

[8] FRANKLIN C. KINSEY, civil engineer, Soil Conservation Service, helped prepare this section.

Engineering classification systems

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

In the Unified system soils are classified according to particle size distribution, plasticity, liquid limit, and organic matter (*10*, *14*). Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL. The estimated Unified classification is given in table 5 for all soils mapped in the survey area.

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance (*1*, *10*). In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. If a soil is near a classification boundary, it is given a symbol showing both classes, such as A-2 or A-4. The estimated AASHO classification is given in table 5 for all soils mapped in the survey area.

Engineering properties

Several estimated soil properties significant to engineering are given in table 5. These estimates are made for representative soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 5.

Depth to bedrock is distance from the surface of the soil to the upper surface of the rock layer. The bedrock is unweathered shale or consolidated limestone.

Depth from surface differs slightly from the descriptions of the representative profiles given in the section "Descriptions of the Soils." Adjacent layers that have similar USDA textures and Unified and AASHO classifications are combined into one layer in table 5.

Soil texture is described in table 5 in the standard terms used by the U.S. Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

TABLE 5.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in referring to other series that appear in the first column of this

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Ft.	*In.*			
Alluvial land: Ad. Too variable to be rated.					
*Benfield: Bf For Florence part, see Florence series.	2–3½	0–12 12–26 26–35 35	Silty clay loam Silty clay Silty clay loam Shale.	CL CH CL or CH	A–7 A–7 A–7
Breaks-Alluvial land complex: Bk. Too variable to be rated.					
*Carr: Ca For Sarpy part, see Sarpy series.	>10	0–28 28–60	Fine sandy loam Very fine sandy loam	SM or ML ML	A–4 A–4
Chase: Ch	>10	0–13 13–60	Silty clay loam Silty clay	CL CH	A–7 A–7
*Clime: Cs For Sogn part, see Sogn series.	1½–3½	0–30 30	Silty clay loam Shale.	CL or CH	A–7
*Dwight: Dr, Dw For Irwin parts of Dr and Dw, see Ic and Id under the Irwin series, respectively.	3½–5	0–4 4–43 43–48 48	Silt loam Silty clay Shale. Limestone.	ML or ML–CL CH	A–4 or A–6 A–7
*Elmont: Em, En For Clime part of En, see Clime series.	3–5	0–10 10–33 33–44 44	Silt loam Silty clay loam Clay loam Silty and sandy shale.	ML or ML–CL CL CL	A–4 or A–6 A–6 or A–7 A–6 or A–7
Eudora: Eu	>10	0–18 18–36 36–62	Silt loam Very fine sandy loam Silt loam	ML or ML–CL ML or ML–CL ML or ML–CL	A–4 A–4 A–4
Florence [1] Mapped only in a complex with Benfield soils.	2–3½	0–5 5–10 10–30 30	Cherty silt loam Cherty silty clay loam Cherty clay and silty clay Cherty limestone.	ML or CL GC, GM, CL, or ML GC or CH	A–4 or A–6 A–2 or A–6 A–2 or A–7
Geary: Ga, Ge	>4	0–8 8–60	Silt loam Silty clay loam	ML or ML–CL CL or ML	A–4 A–6 or A–4
Haynie: Ha	>10	0–10 10–20 20–41 41–60	Very fine sandy loam Silt loam Very fine sandy loam Silty clay loam	ML ML ML ML–CL or CL	A–4 A–4 A–4 A–6
Irwin:					
Ic	3½–6	0–11 11–55 55	Silty clay loam Silty clay Limestone or shale.	CL CH	A–6 A–7
Id	3½–6	0–6 6–50 50	Heavy silty clay loam Silty clay Limestone or shale.	CH CH	A–7 A–7
*Ivan:					
Ie	≥4	0–60	Silty clay loam	CL	A–6 or A–7
Iv For Kennebec part of Iv, see Kennebec series.	>4	0–7 7–60	Silt loam Light silty clay loam	CL CL	A–6 A–6

See footnote at end of table.

significant to engineering

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for table. The sign > means more than; the sign < means less than]

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				In. per hr.	*In. per in. of soil*	*pH*	
90–100	90–100	90–100	80–95	0. 20–0. 60	0. 17–0. 19	6. 6–7. 8	Moderate.
90–100	90–100	90–100	85–100	0. 06–0. 20	0. 17–0. 19	6. 6–8. 4	High.
85–100	85–95	85–95	75–90	0. 10–0. 60	0. 17–0. 19	7. 4–8. 4	Moderate or high.
100	100	70–85	40–55	1. 00–8. 00	0. 11–0. 13	7. 9–8. 4	Low.
100	100	85–95	50–65	0. 60–8. 00	0. 16–0. 18	7. 9–8. 4	Low.
100	100	95–100	90–100	0. 20–0. 60	0. 17–0. 19	5. 6–7. 0	Moderate.
100	100	95–100	90–100	0. 06–0. 20	0. 17–0. 19	5. 6–8. 0	High.
95–100	95–100	85–95	80–95	0. 20–0. 60	0. 17–0. 19	7. 4–8. 4	Moderate.
100	100	95–100	95–100	0. 20–0. 60	0. 16–0. 18	5. 6–7. 0	Low.
100	100	95–100	95–100	<0. 06	0. 17–0. 19	5. 6–8. 0	High.
100	100	90–100	70–90	0. 63–2. 00	0. 16–0. 18	5. 6–6. 5	Low.
100	100	95–100	85–95	0. 20–0. 60	0. 17–0. 19	5. 6–7. 0	Moderate.
100	100	90–100	70–80	0. 20–0. 60	0. 17–0. 19	6. 1–7. 3	Moderate.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	6. 1–7. 3	Low.
100	100	85–95	50–65	0. 60–2. 00	0. 16–0. 18	6. 6–8. 0	Low.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	6. 6–8. 4	Low.
60–100	60–94	60–90	56–86	0. 60–2. 00	0. 14–0. 16	6. 1–7. 3	Moderate.
20–80	16–76	16–70	16–66	0. 20–0. 60	0. 06–0. 08	6. 1–7. 3	Low.
20–75	16–70	16–70	16–66	0. 20–0. 60	0. 04–0. 06	6. 1–7. 8	Low.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	5. 6–6. 5	Low.
100	100	95–100	85–95	0. 60–2. 00	0. 17–0. 19	6. 1–7. 8	Moderate.
100	100	85–95	50–65	0. 60–2. 00	0. 16–0. 18	7. 9–8. 4	Low.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	7. 9–8. 4	Low.
100	100	85–95	50–65	0. 60–2. 00	0. 16–0. 18	7. 9–8. 4	Low.
100	100	95–100	85–95	0. 60–2. 00	0. 17–0. 19	7. 9–8. 4	Low.
95–100	95–100	90–100	90–100	0. 60–2. 00	0. 17–0. 19	5. 6–7. 3	Moderate.
95–100	95–100	90–100	90–100	<0. 06	0. 17–0. 19	6. 1–7. 8	High.
95–100	95–100	90–100	90–100	0. 20–0. 60	0. 17–0. 19	5. 6–7. 3	High.
95–100	95–100	90–100	90–100	<0. 06	0. 17–0. 19	6. 1–7. 8	High.
95–100	90–100	85–100	75–90	0. 60–2. 00	0. 17–0. 19	7. 9–8. 4	Moderate.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	7. 9–8. 4	Moderate.
100	100	90–100	85–95	0. 60–2. 00	0. 17–0. 19	7. 9–8. 4	Moderate.

TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Ft.	*In.*			
Kahola: Ka	>10	0–13	Silt loam	ML or ML–CL	A–4 or A–6
		13–60	Silty clay loam	CL	A–6 or A–7
Kenesaw: Ke, Kf	>4	0–60	Silt loam	ML	A–4
Kennebec	>4	0–18	Heavy silt loam	CL	A–6
Mapped only in an undifferentiated group with Ivan soils.		18–60	Light silty clay loam	CL	A–6
Mayberry:					
Ma	>4	0–13	Clay loam	ML–CL or CL	A–6
		13–58	Clay	CH	A–7
		58–64	Heavy clay loam	CH	A–7
Mb	>4	0–7	Clay loam	CL	A–6 or A–7
		7–52	Clay	CH	A–7
		52–60	Heavy clay loam	CH	A–7
Muir: Mu	>10	0–60	Silt loam	ML or CL	A–4 or A–6
Reading: Rd, Re	>4	0–11	Silt loam	CL	A–6
		11–60	Silty clay loam	CH or CL	A–7
Sarpy: Sa	>10	0–5	Loamy fine sand	SM	A–2 or A–4
		5–53	Fine sand	SM or SP–SM	A–2 or A–3
		53–60	Very fine sandy loam	ML	A–4
Smolan:					
Sm, Sn	>4	0–8	Silt loam	CL or ML–CL	A–6
		8–60	Silty clay loam	CH or CL	A–7
So	>4	0–60	Silty clay loam	CH or CL	A–7
Sogn	½–1½	0–9	Silty clay loam	CL	A–6 or A–7
Mapped only in a complex with Clime soils.		9	Limestone.		
Stony steep land: St. Too variable to be rated.					
Sutphen: Su	>10	0–60	Silty clay	CH	A–7
Tully:					
Ts, Tu	>4	0–16	Silty clay loam	CL	A–7
		16–60	Silty clay	CH	A–7
Tt, Tv	>4	0–7	Silty clay loam	CL or CH	A–7
		7–60	Silty clay	CH	A–7
Wymore:					
Wm, Wn, Wr	>4	0–13	Silty clay loam	CL	A–6
		13–33	Silty clay	CH	A–7
		33–64	Silty clay loam	CL or CH	A–7
Wo, Ws	>4	0–7	Silty clay loam	CL or CH	A–6 or A–7
		7–27	Silty clay	CH	A–7
		27–60	Silty clay loam	CL or CH	A–7

[1] The content of fragments larger than 3 inches in diameter is estimated to be 0 to 40 percent in the 0 to 5-inch layer and 0 to 75 percent
inches make up 50 to 85

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)				
				In. per hr.	*In. per in. of soil*	*pH*	
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	6. 6–7. 8	Low.
100	100	95–100	85–95	0. 60–2. 00	0. 17–0. 19	7. 4–8. 4	Moderate.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	5. 6–7. 3	Low.
100	100	90–100	70–90	0. 60–2. 00	0. 17–0. 19	6. 6–7. 8	Moderate.
100	100	90–100	85–100	0. 60–2. 00	0. 17–0. 19	6. 6–7. 8	Moderate.
95–100	95–100	85–100	65–80	0. 20–0. 60	0. 17–0. 19	5. 6–6. 5	Low.
95–100	95–100	85–100	70–95	0. 06–0. 20	0. 17–0. 19	6. 1–8. 0	High.
95–100	95–100	85–100	65–80	0. 20–0. 60	0. 17–0. 19	7. 4–8. 4	High.
95–100	95–100	85–100	65–80	0. 20–0. 60	0. 17–0. 19	5. 6–6. 5	Moderate.
95–100	95–100	85–100	70–95	0. 06–0. 20	0. 17–0. 19	6. 1–8. 0	High.
95–100	95–100	85–100	65–80	0. 20–0. 60	0. 17–0. 19	7. 4–8. 4	High.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	6. 1–7. 8	Low.
100	100	90–100	70–90	0. 60–2. 00	0. 16–0. 18	5. 6–6. 5	Moderate.
100	100	95–100	85–95	0. 20–0. 60	0. 17–0. 19	5. 6–8. 4	High or moderate.
100	100	70–85	25–45	>20. 00	0. 06–0. 08	7. 9–8. 4	Low.
100	100	65–80	5–35	>20. 00	0. 06–0. 08	7. 9–8. 4	Low.
100	100	85–95	50–65	>20. 00	0. 16–0. 18	7. 9–8. 4	Low.
100	100	90–100	70–90	0. 20–0. 60	0. 16–0. 18	5. 6–7. 3	Moderate.
100	100	95–100	85–95	0. 06–0. 20	0. 17–0. 19	6. 1–7. 3	High or moderate.
100	100	95–100	85–95	0. 06–0. 20	0. 17–0. 19	5. 6–7. 3	High or moderate.
95–100	95–100	90–100	80–95	0. 60–2. 00	0. 17–0. 19	6. 1–8. 4	Moderate.
100	100	95–100	95–100	<0. 06	0. 17–0. 19	6. 1–8. 4	High.
95–100	95–100	90–100	80–95	0. 20–0. 60	0. 17–0. 19	5. 6–7. 3	Moderate.
95–100	95–100	90–100	80–95	0. 06–0. 20	0. 17–0. 19	6. 1–8. 4	High.
95–100	95–100	90–100	80–95	0. 20–0. 60	0. 17–0. 19	5. 6–7. 3	Moderate or high.
95–100	95–100	90–100	80–95	0. 06–0. 20	0. 17–0. 19	6. 1–8. 4	High.
100	100	95–100	95–100	0. 20–0. 60	0. 17–0. 19	5. 6–6. 5	Moderate.
100	100	95–100	95–100	0. 06–0. 20	0. 17–0. 19	6. 1–7. 3	High.
100	100	95–100	95–100	0. 20–0. 60	0. 17–0. 19	6. 6–7. 8	Moderate or high.
100	100	95–100	95–100	0. 20–0. 60	0. 17–0. 19	5. 6–6. 5	Moderate or high.
100	100	95–100	95–100	0. 06–0. 20	0. 17–0. 19	6. 1–7. 3	High.
100	100	95–100	95–100	0. 20–0. 60	0. 17–0. 19	6. 6–7. 8	Moderate or high.

in the lower two layers. Where the content of fragments larger than 3 inches is near zero in the lower two layers, fragments larger than 1.5 percent of the layers.

TABLE 6.—*Interpretations*

An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have different

Soil series and map symbols	Suitability as source of—				Soil features affecting—		
	Topsoil	Sand and gravel	Road subgrade	Road fill	Highway location	Dikes and levees	Farm pond: Reservoir areas
Alluvial land: Ad. No interpretations made; properties too variable.							
*Benfield: Bf. For Florence part, see Florence series.	Fair: limited quantity of suitable material.	Unsuitable.	Poor: moderate to high shrink-swell potential.	Fair: fair to poor stability; moderate to high shrink-swell potential.	Bedrock at depth of 2 to 3½ feet; irregular topography; slow internal drainage; high plasticity.	Fair to poor stability; subject to cracking; bedrock at depth of of 2 to 3½ feet.	Slow permeability; bedrock at depth of 2 to 3½ feet.
Breaks-Alluvial land complex: Bk. No interpretations made; properties too variable.							
*Carr: Ca. For Sarpy part, see Sarpy series.	Fair: sandy loam material.	Poor for fine sand; unsuitable for gravel.	Good.	Good if confined.	Nearly level: subject to flooding.	Fair to poor stability; erodible.	Moderate to rapid permeability; nearly level.
Chase: Ch.	Good.	Unsuitable.	Poor: high shrink-swell potential.	Fair: fair to poor stability.	Slow internal drainage; nearly level; high plasticity.	Fair to poor stability; subject to cracking.	Nearly level; slow permeability.
*Clime: Cs. For Sogn part, see Sogn series.	Fair: limited quantity of suitable material.	Unsuitable.	Fair: moderate shrink-swell potential.	Good.	Bedrock at depth of 1½ to 3½ feet; irregular topography; moderate plasticity; possible seepage.	Fair to poor stability; subject to cracking; possible loose rocks; bedrock at depth of 1½ to 3½ feet.	Bedrock at depth of 1½ to 3½ feet may allow seepage
*Dwight: Dr, Dw. For Irwin part, see Irwin series.	Poor: limited quantity of suitable material.	Unsuitable.	Poor: high shrink-swell potential.	Poor: poor stability; possible dispersion; high shrink-swell potential.	Very slow internal drainage; slope of 1 to 4 percent; high plasticity.	Fair to poor stability: subject to cracking.	Slope of 1 to 4 percent; very slow permeability; bedrock at depth of 3½ to 6 feet.
*Elmont: Em, En. For Clime part of En, see Clime series.	Fair: material below depth of 10 inches is more clayey and is lower in fertility.	Unsuitable.	Poor: moderate shrink-swell potential.	Good.	Bedrock at depth of 3 to 5 feet; slope of 3 to 15 percent.	No unfavorable features.	Silty or sandy bedrock at depth of 3 to 5 feet may allow seepage.
Eudora: Eu.	Good.	Unsuitable.	Poor: poor stability.	Fair to poor: erodible.	Nearly level.	Poor stability; erodible.	Moderate permeability; nearly level; pervious material in substratum.
Florence. Mapped only in a complex with Benfield soils.	Poor: limited quantity of suitable material.	Unsuitable for sand; fair for angular chert.	Good to poor, depending on size of chert fragments.	Good.	Bedrock at depth of 2 to 3½ feet; angular chert fragments make up 50 to 85 percent; irregular topography.	Angular chert fragments make up 50 to 85 percent; bedrock at depth of 2 to 3½ feet.	Fractured rock may allow seepage.

of engineering properties

properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Soil features affecting—Continued						Degree and kind of limitations for—	
Farm pond—Con. Embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings	Septic tank absorption fields	Sewage lagoons
Fair to poor stability and compaction; high compressibility; moderate to high shrink-swell potential; bedrock at depth of 2 to 3½ feet.	Slope of 8 to 20 percent; slow permeability.	Slope of 8 to 20 percent; bedrock at depth of 2 to 3½ feet; slow infiltration rate.	Slope of 8 to 20 percent; bedrock at depth of 2 to 3½ feet.	Slope of 8 to 20 percent; bedrock at depth of 2 to 3½ feet.	Low shear strength; moderate to high shrink-swell potential; slow permeability; bedrock at depth of 2 to 3½ feet.	Severe: slow permeability; slope of 8 to 20 percent; bedrock at depth of 2 to 3½ feet.	Severe: bedrock at depth of 2 to 3½ feet; slope of 8 to 20 percent.
Fair to poor stability and compaction; moderate to rapid permeability, highly erodible.	Nearly level; moderate to rapid permeability.	Moderate to high available water capacity; moderate to rapid infiltration rate; susceptible to soil blowing; subject to flooding.	Nearly level; erodible; fair to poor stability; subject to flooding.	Nearly level; erodible; fair to poor stability; subject to flooding.	Subject to flooding..	Moderate: subject to flooding; moderate to rapid permeability may allow pollution of water supply.	Moderate to severe; moderate to rapid permeability.
Subsoil has fair to poor stability and compaction; high compressibility; high shrink-swell potential.	Nearly level; slow permeability; somewhat poorly drained under natural conditions.	High available water capacity; slow infiltration rate.	Nearly level.....	Nearly level.....	Low shear strength; high shrink-swell potential; slow permeability.	Severe: slow permeability.	Slight.
Fair to poor stability and compaction; medium to high compressibility; moderate shrink-swell potential; bedrock at depth of 1½ to 3½ feet.	Possible seepage; slope of 5 to 20 percent; moderately slow permeability.	Bedrock at depth of 1½ to 3½ feet; slope of 5 to 20 percent.	Bedrock at depth of 1½ to 3½ feet; slope of 5 to 20 percent.	Bedrock at depth of 1½ to 3½ feet; slope of 5 to 20 percent.	Moderate to low shear strength; bedrock at depth of 1½ to 3½ feet; moderate shrink-swell potential.	Severe: moderately slow permeability; slope of 5 to 20 percent; bedrock at depth of 1½ to 3½ feet.	Severe: bedrock at depth of 1½ to 3½ feet; slope of 5 to 20 percent.
Fair to poor stability and compaction; high compressibility; high shrink-swell potential.	Slope of 1 to 4 percent; very slow permeability.	Very slow infiltration rate; sodium hazard.	Thin surface layer; dense clayey subsoil; sodium hazard.	Thin surface layer; dense, clayey subsoil; sodium hazard.	Low shear strength; high shrink-swell potential; very slow permeability.	Severe: very slow permeability.	Moderate: bedrock at depth of 3½ to 5 feet.
Surface layer has poor stability and compaction; shale at depth of 3 to 5 feet.	Slope of 3 to 15 percent; moderately slow permeability.	Slope of 3 to 15 percent.	Slope of 3 to 15 percent.	Slope of 3 to 15 percent.	Bedrock at depth of 3 to 5 feet.	Severe: moderately slow permeability; bedrock at depth of 3 to 5 feet.	Severe: bedrock at depth of 3 to 5 feet; slope of 3 to 15 percent.
Poor stability and compaction; erodible.	Nearly level; moderate permeability.	High available water capacity; nearly level.	Nearly level; erodible.	Nearly level; erodible.	Low shear strength..	Slight.....	Moderate: moderate permeability.
Angular chert fragments make up 50 to 85 percent; bedrock at depth of 2 to 3½ feet.	Slope of 5 to 20 percent; moderately slow permeability; angular chert fragments make up 50 to 85 percent.	Bedrock at depth of 2 to 3½ feet; slope of 5 to 20 percent; chert fragments make up 50 to 85 percent.	Bedrock at depth of 2 to 3½ feet; angular chert fragments make up 50 to 85 percent.	Bedrock at depth of 2 to 3½ feet; angular chert fragments make up 50 to 85 percent.	Bedrock at depth of 2 to 3½ feet; angular chert fragments make up 50 to 85 percent.	Severe: moderately slow permeability; bedrock at depth of 2 to 3½ feet.	Severe: bedrock at depth of 2 to 3½ feet; slope of 5 to 20 percent; angular chert fragments make up 50 to 85 percent.

TABLE 6.—*Interpretations of*

Soil series and map symbols	Suitability as source of—				Soil features affecting—		
	Topsoil	Sand and gravel	Road subgrade	Road fill	Highway location	Dikes and levees	Farm pond
							Reservoir areas
Geary: Ga, Ge	Good	Unsuitable	Fair to poor: moderate shrink-swell potential.	Good	Slope of 1 to 8 percent.	Fair to poor stability; moderate shrink-swell potential.	Moderate permeability; slope of 1 to 8 percent.
Haynie: Ha	Good	Unsuitable	Poor: poor stability.	Fair to poor: erodible.	Subject to flooding; nearly level.	Poor stability; erodible.	Moderate permeability; nearly level; pervious material in substratum.
Irwin: Ic, Id	Fair: limited quantity of suitable material.	Unsuitable	Poor: high shrink-swell potential.	Fair: fair to poor stability; high shrink-swell potential.	Very slow internal drainage; slope of 1 to 8 percent; high plasticity.	Fair to poor stability; subject to cracking.	Very slow permeability; bedrock at a depth of 3½ to 6 feet; slope of 1 to 8 percent.
Ivan:							
Ie	Fair to good: few stones in places.	Unsuitable	Poor: poor stability.	Good	Slope of 1 to 3 percent.	No unfavorable features.	Moderate permeability; stratified with pervious material in some places; slope of 1 to 3 percent.
Iv. For Kennebec part of IV see Kennebec series.	Good	Unsuitable	Poor: poor stability.	Good	Subject to flooding; nearly level.	No unfavorable features.	Moderate permeability; stratified with pervious material in some places; nearly level.
Kahola: Ka	Good	Unsuitable	Poor: poor stability.	Good	Subject to flooding; nearly level.	No unfavorable features.	Moderate permeability; nearly level; pervious material in substratum in some places.
Kenesaw: Ke, Kf	Good	Unsuitable	Poor: poor stability.	Fair to poor; erodible.	Slope of 2 to 10 percent; erodible.	Poor stability; erodible.	Moderate permeability; slope of 2 to 10 percent.
Kennebec. Mapped only in an undifferentiated group with Ivan soils.	Good	Unsuitable	Poor: poor stability.	Good	Subject to flooding; nearly level.	No unfavorable features.	Moderate permeability; stratified with pervious material in some places; nearly level.
Mayberry: Ma, Mb	Fair to poor: limited quantity of suitable material.	Unsuitable	Poor: high shrink-swell potential.	Fair: fair to poor stability.	Slow internal drainage; slope of 2 to 6 percent; high plasticity.	Fair to poor stability; subject to cracking.	Slope of 2 to 6 percent; slow permeability.

engineering properties—Continued

Soil features affecting—Continued						Degree and kind of limitations for—	
Farm pond—Con. Embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings	Septic tank absorption fields	Sewage lagoons
Fair to poor stability and compaction.	Slope of 1 to 8 percent; moderate permeability.	High available water capacity; slope of 1 to 8 percent.	No unfavorable features.	No unfavorable features.	No unfavorable features.	Moderate: moderate permeability; slope of 1 to 8 percent.	Moderate where slopes are more than 2 percent or if material is mostly ML; slight where slopes are less than 2 percent and material is CL.
Poor stability and compaction; erodible.	Nearly level; moderate permeability; subject to flooding.	High available water capacity; nearly level; subject to flooding; susceptible to soil blowing.	Nearly level; subject to flooding; erodible.	Nearly level; subject to flooding; erodible.	Low shear strength.	Moderate: subject to flooding.	Moderate: moderate permeability.
Fair to poor stability and compaction; high compressibility; high shrink-swell potential.	Slope of 1 to 8 percent; very slow permeability.	High available water capacity; slope of 1 to 8 percent; very slow infiltration rate.	Clayey subsoil	Clayey subsoil	Low shear strength; high shrink-swell potential; very slow permeability; bedrock at depth of 3½ to 6 feet.	Severe: very slow permeability; bedrock at depth of 3½ to 6 feet.	Moderate where slopes are less than 7 percent; severe where slopes are more than 7 percent: bedrock at a depth of 3½ to 6 feet.
No unfavorable features.	Slope of 1 to 3 percent; moderate permeability.	High available water capacity; slope of 1 to 3 percent.	On alluvial fan that receives runoff from steep slopes.	On alluvial fan that receives runoff from steep slopes.	Moderate shrink-swell potential.	Moderate: moderate permeability.	Slight to moderate: slope of 1 to 3 percent; moderate permeability.
No unfavorable features.	Nearly level; moderate permeability; subject to flooding.	High available water capacity; nearly level; subject to flooding.	Nearly level; subject to flooding.	Nearly level; subject to flooding.	Moderate shrink-swell potential; subject to flooding.	Severe: moderate permeability; subject to flooding.	Moderate if protected from flooding; severe if not protected; moderate permeability.
Surface layer has poor stability and compaction.	Nearly level; moderate permeability; subject to flooding.	High available water capacity; nearly level; subject to flooding.	Nearly level; subject to flooding.	Nearly level; subject to flooding.	Moderate shrink-swell potential.	Moderate: moderate permeability; subject to flooding.	Moderate: moderate permeability.
Poor stability and compaction; erodible.	Slope of 2 to 10 percent; moderate permeability.	High available water capacity; slope of 2 to 10 percent.	Erodible; poor stability.	Erodible; poor stability.	Low shear strength.	Slight where slopes are less than 5 percent; moderate where slopes are more than 5 percent.	Moderate where slopes are less than 7 percent; severe where slopes are more than 7 percent; moderate permeability.
No unfavorable features.	Nearly level; moderate permeability; subject to flooding.	High available water capacity; nearly level; subject to flooding.	Nearly level; subject to flooding.	Nearly level; subject to flooding.	Moderate shrink-swell potential; subject to flooding.	Severe: moderate permeability; subject to flooding.	Moderate if protected from flooding; severe if not protected; moderate permeability.
Fair to poor stability and compaction; high compressibility; high shrink-swell potential.	Slope of 2 to 6 percent; slow permeability.	High available water capacity; slope of 2 to 6 percent; slow intake rate.	Clayey subsoil	Clayey subsoil	Low shear strength; high shrink-swell potential; slow permeability.	Severe: slow permeability.	Moderate: slope of 2 to 6 percent.

TABLE 6.—*Interpretations of*

Soil series and map symbols	Suitability as source of—				Soil features affecting—		
	Topsoil	Sand and gravel	Road subgrade	Road fill	Highway location	Dikes and levees	Farm pond
							Reservoir areas
Muir: Mu	Good	Unsuitable	Fair to poor: fair to poor stability.	Good	Nearly level	Fair to poor stability	Moderate permeability; nearly level.
Reading: Rd, Re	Good	Unsuitable	Poor: moderate to high shrink-swell potential.	Fair to good: fair stability.	Slope of 0 to 3 percent.	No unfavorable features.	Slope of 0 to 3 percent; moderately slow permeability.
Sarpy: Sa	Poor: sandy material.	Fair for fine sand; unsuitable for gravel.	Good	Good if confined	Nearly level; subject to flooding.	Poor stability	Very rapid permeability; nearly level.
Smolan: Sm, Sn, So	Good	Unsuitable	Poor: moderate to high shrink-swell potential.	Fair: fair to poor stability; moderate to high shrink-swell potential.	Slow internal drainage; slope of 1 to 8 percent; high plasticity.	Fair to poor stability; subject to cracking.	Slope of 1 to 8 percent; slow permeability.
Sogn Mapped only in complex with Clime soils.	Poor: limited quantity of suitable material.	Unsuitable: possible source of crushable rock.	Poor: moderate shrink-swell potential.	Good	Bedrock at a depth of ½ to 1½ feet; slope of 5 to 8 percent; moderate plasticity.	Bedrock at depth of ½ to 1½ feet.	Limestone bedrock at depth of ½ to 1½ feet; moderate permeability.
Stony steep land: St. No interpretations made; properties too variable.							
Sutphen: Su	Poor: clayey material.	Unsuitable	Poor: high shrink-swell potential.	Fair: poor stability; high shrink-swell potential.	Nearly level; very slow internal drainage; poor surface drainage; high plasticity.	Poor stability; subject to cracking.	Nearly level; very slow permeability.
Tully: Ts, Tt, Tu, Tv.	Good in Ts and Tu; fair in Tt and Tv.	Unsuitable	Poor: high shrink-swell potential.	Fair: fair to poor stability; high shrink-swell potential.	Slow internal drainage; slope of 1 to 8 percent; high plasticity.	Fair to poor stability; subject to cracking.	Slope of 1 to 8 percent; slow permeability.
Wymore: Wm, Wn, Wo, Wr, Ws.	Fair: clayey material below a depth of about 13 inches.	Unsuitable	Poor: shrink-swell potential.	Fair: fair to poor stability; high shrink-swell potential.	Slow internal drainage; slope of 0 to 8 percent; high plasticity.	Fair to poor stability; subject to cracking.	Slope of 0 to 8 percent.

engineering properties—Continued

Soil features affecting—Continued						Degree and kind of limitations for—	
Farm pond—Con. Embankments	Drainage for crops and pasture	Irrigation	Terraces and diversions	Grassed waterways	Foundations for low buildings	Septic tank absorption fields	Sewage lagoons
Fair to poor stability and compaction.	Nearly level; moderate permeability.	High available water capacity; nearly level.	Nearly level.	Nearly level.	Moderate to low shear strength.	Moderate: moderate permeability.	Moderate: moderate permeability.
Fair stability; fair to poor compaction; medium to high compressibility; moderate to high shrink-swell potential.	Slope of 0 to 3 percent; moderately slow permeability.	High available water capacity; slope of 0 to 3 percent.	Slope of 0 to 3 percent.	Slope of 0 to 3 percent.	Moderate to low shear strength; moderate to high shrink-swell potential.	Severe: moderately slow permeability.	Slight: moderate where slopes are more than 2 percent.
Poor stability; very rapid permeability; highly erodible.	Nearly level; very rapid permeability.	Low available water capacity; nearly level; very rapid intake rate; subject to flooding; susceptible to soil blowing.	Nearly level; highly erodible; poor stability; very rapid permeability; subject to flooding.	Nearly level; highly erodible; poor stability; low available water capacity; subject to flooding.	Very rapid permeability; some areas have a high water table when river is higher.	Moderate: subject to flooding; very rapid permeability may allow pollution of water supply.	Severe: very rapid permeability.
Fair to poor stability and compaction; subsoil has medium to high compressibility and moderate to high shrink-swell potential.	Slope of 1 to 8 percent; slow permeability.	High available water capacity; slope of 1 to 8 percent; slow intake rate.	Clayey subsoil.	Clayey subsoil.	Low shear strength; moderate to high shrink-swell potential; slow permeability.	Severe: slow permeability.	Slight if slope is less than 2 percent; moderate if slope is more than 2 percent.
Bedrock at depth of ½ to 1½ feet.	Slope of 5 to 8 percent; moderate permeability; bedrock at depth of ½ to 1½ feet.	Bedrock at depth of ½ to 1½ feet.	Bedrock at depth of ½ to 1½ feet.	Bedrock at depth of ½ to 1½ feet.	Bedrock at depth of ½ to 1½ feet.	Severe: bedrock at depth of ½ to 1½ feet.	Severe: bedrock at depth of ½ to 1½ feet; moderate permeability.
Poor stability; fair to poor compaction; high compressibility; high shrink-swell potential.	Nearly level; very slow permeability; somewhat poorly drained to moderately well drained.	High available water capacity; nearly level; very slow intake rate.	Nearly level; clayey; very slow permeability.	Nearly level; clayey.	Low shear strength high shrink-swell potential; very slow permeability.	Severe: very slow permeability.	Slight.
Fair to poor stability and compaction; high compressibility; high shrink-swell potential.	Slope of 1 to 8 percent; slow permeability.	High available water capacity; slope of 1 to 8 percent; slow intake rate.	Clayey subsoil.	Clayey subsoil.	Low shear strength; high shrink-swell potential; slow permeability.	Severe: slow permeability.	Moderate where slopes are 2 to 7 percent; severe where slopes are more than 7 percent.
Fair to poor stability and compaction; high compressibility; high shrink-swell potential.	Slope of 0 to 8 percent; slow permeability.	High available water capacity; slope of 0 to 8 percent; slow intake rate.	Clayey subsoil.	Clayey subsoil.	Low shear strength; high shrink-swell potential; slow permeability.	Severe: slow permeability.	Moderate where slopes are 2 to 7 percent; severe where slopes are more than 7 percent.

The percentage of material passing various sizes of sieves indicates the relative amounts of coarse- and fine-grained materials. Silt and clay will pass through a No. 200 sieve, but sand and coarser textured material will not. In table 5, 100 percent of the material that is up to and including 3 inches in diameter is assumed to pass through the sieves; only material that is less than 3 inches in diameter is listed in these columns.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on basis of those soil characteristics observed in the field, particularly structure and texture. Th estimates in table 5 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

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

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values for a soil-water ratio of 1 : 1. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Seasonal high water table is not included in table 5. Seasonal wetness is a problem in the Chase and Sutphen soils. Flooding is a hazard on the Carr, Haynie, Ivan, Kahola, and Kennebec soils, on Alluvial land, and on the Alluvial land part of Breaks-Alluvial land complex. More detailed information on flooding can be obtained from the section "Descriptions of the Soils."

More than 50 percent of the soils in the county have a high shrink-swell potential and a slowly permeable subsoil. Less than 10 percent of the soils have a low shrink-swell potential, and most of these are in the valleys of the Kansas and Republican Rivers.

About 25 percent of the soils are less than 3½ feet deep to bedrock, and more than 15 percent have slopes that are more than 8 percent. There are few, if any, sources of coarse sand and rounded gravel, but sources of crushable limestone and chert are common. Some material suitable for topsoil is available in nearly all areas, but the largest source is from the soils in creeks and river valleys.

Engineering interpretations[9]

The estimated interpretations in table 6 are based on the estimated properties of soils shown in table 5, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of the survey area. In table 6, ratings are used to summarize the limitation or suitability of the soils. Soil features not to be overlooked in planning, installation, and maintenance of structures are listed.

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

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

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

The suitability rating for road subgrade material depends mainly on the grain size and the amount of silt and clay. In general, a sandy material that contains an adequate binder is the best. The poorest material is plastic clay.

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

Highway location is influenced by features of the undisturbed soil that affect construction and maintenance of highways. The soil features, favorable as well as unfavorable, are the principal ones that affect the geographic location of highways.

Dikes and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactability. Presence of stones or organic material in a soil are among many factors that are unfavorable.

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

Farm pond embankments serve as dams. Both the subsoil and substratum are evaluated in places where they have significant thickness for use as borrow in constructing embankments.

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

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumu-

[9] NORMAN CLARK and HERBERT E. WORLEY, engineers, Kansas State Highway Commission, helped prepare this section.

lations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Grassed waterways are vegetated, natural or artificial waterways used to conduct the accumulated runoff from cultivated and uncultivated land. They are designed to prevent gully erosion. Among the soil features affecting grassed waterways are fertility, slope, drainage, erodibility, depth to the subsoil or substratum, soil reaction, depth to the water table, and the hazard of flooding.

Foundations for low buildings are rated for dwellings that are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, shear strength, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, permeability, depth to bedrock, and contents of stones and rocks.

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

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

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

Formation and Classification of Soils

This section shows how the factors of soil formation have affected the development of soils in the survey area. It also explains the system of soil classification currently used and places each soil series in some of the higher categories of that system.

Factors of Soil Formation

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

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

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

Parent material

The parent material of most of the soils on uplands in the survey area is material weathered from bedrock, glacial drift, and loess. The soils on the bottom lands developed in alluvium.

Bedrock.—Most layers of the consolidated bedrock that crops out in the survey area are members of the Permian System (*6*). Some layers of the Pennsylvanian System crop out south of the Kansas River in the eastern part of the county. These bedrock layers are alternate strata of shale and limestone, except for a discontinuous sandstone layer near the base of the Permian System. Some of the weathering material was transported short distances down the hill by water and gravity before much

soil development took place. The main soils that developed in material weathered from these rocks are the Clime, Sogn, Benfield, Florence, Dwight, Irwin, Tully, and Elmont soils.

Glacial drift.—Glacial drift includes the materials deposited by glaciers and by the streams and lakes associated with them. In the survey area the material was probably deposited in the Kansas stage of Pleistocene time (*15*). The drift consists mostly of clayey and silty material, but it contains some coarse sand grains and rock fragments, and a few quartzite boulders several feet in diameter. The clayey and silty material was derived through the reworking of weathered limestone and shale. This finer material probably has been moved less than 10 miles from its source. Some of the quartzitic stones and boulders may have been moved hundreds of miles. Most of the glacial drift was deposited in the northern part of Riley County, generally north of Fancy Creek. Some smaller deposits occur on the uplands near Zeandale. Mayberry soils formed in glacial drift.

Loess.—Loess is windblown material that probably was first deposited on the flood plains of streams swollen by melting glacial ice and later moved and redeposited on higher ground by the wind. Loess deposits consist of relatively uniform, fine material that is mostly silt and clay. Loess of several different ages is in the survey area. Loveland loess was deposited during the Illinoian and early Sangamonian stages of Pleistocene time. The Geary and Smolan soils developed in this loess on uplands near the Kansas, Republican, and Big Blue Rivers. Peoria loess was deposited during the Wisconsin stage of Pleistocene time. Wymore soils developed in the Peoria loess. Peoria loess deposits are in all parts of the survey area, and the deepest deposits are near Riley. The most recent loess in the survey area is on the north wall of the valleys of the Kansas and Republican Rivers. The weakly developed Kenesaw soils formed in this loess.

Alluvium.—Alluvium consists of sediments deposited on land by streams. The alluvium in the smaller stream valleys is mostly local material, accumulated mainly by the downwash of weathered shale and loess from the valley walls. Gravel in this alluvium is mostly fragments of chert, limestone, and shale. The Ivan, Kennebec, and Reading soils developed in this kind of alluvium. The alluvium in the valleys of the Kansas, Big Blue, and Republican Rivers consists of some locally derived material and some material carried downstream from areas 100 to 300 miles north and west of the survey area. Granitic material makes up the greater part of the gravel in this alluvium. Alluvial deposits along the rivers are 50 feet or more thick, but deposits in the creek valleys are much thinner. Soils that developed in alluvium in the larger stream valleys are the Sutphen, Chase, Muir, Kahola, Haynie, Carr, and Sarpy.

Climate

Climate affects the formation of the soils in several ways. A first step in the formation of soils is the disintegration of rocks and other materials deposited on the land surface. Rain, snow, and ice, as well as variations in temperature, are active agents in disintegration.

The amount of water that percolates through the soil determines the rate at which minerals are leached and fine soil particles are moved downward. It also affects the depth at which clay and mineral particles accumulate in the soil profile. The fine-textured subsoil in many of the soils in the survey area is the result of a certain amount of water moving through the soils. The average yearly precipitation in the survey area is about 31½ inches. This amount of precipitation causes the surface layer of many soils to become slightly acid and to require additions of lime.

Temperature and moisture affect the kinds and amounts of plants that grow and of organic matter that is in the soil. Moisture and temperature conditions in the survey area are favorable for the growth of mid and tall native grasses. For this reason, many soils contain a fairly large amount of organic matter and have a thick, dark-colored surface layer.

Alternating cold and warm temperatures in winter cause freezing and thawing of the soil material. This action breaks up the soil aggregates and changes the soil structure. The average maximum temperature in the survey area during January is about 39° F., and the average minimum temperature is 18°. This difference in temperature causes many of the soils in the county to have a friable surface layer that is granular in structure. Alternate drying and wetting of some soil materials results in a shrinking and swelling action that also affects soil structure and consistence.

The frequency and intensity of the wind affect soil formation in several ways. Hot winds in summer evaporate moisture rapidly. Strong winds can blow fine dry particles from the surface layer and decrease the fertility of the soils. Soil blowing can change the texture of the surface layer by winnowing out some of the silt and clay and leaving the sand behind.

Plant and animal life

Plants and animals have a direct influence on soil formation. Plants begin to grow after the parent material is weathered enough to supply nutrients. As soil formation takes place, the amount of biological activity increases.

The roots and tops of decaying plants affect soil structure by adding organic matter to the soils. Plants are the primary source of organic matter that causes the dark color in the surface layer of most soils in the county. Plant residues and organic matter on and mixed in the soil help to increase water intake. The soils in the survey area formed under native grass, and they are fairly high in organic-matter content.

Acids are produced when organic materials decay. These acids help to decompose particles of rocks and extract minerals that are valuable plant nutrients. Soils formed under trees generally are more acid and contain smaller amounts of organic matter than soils formed under grass.

Micro-organisms break down the organic matter, as well as minerals and rocks. Some micro-organisms take nitrogen from the air and help to combine it with other elements in the formation of compounds that nourish plants and encourage their growth.

In addition to micro-organisms, the population of rodents, earthworms, and insects helps to convert nutrients into a form available to plants. Burrowing animals and earthworms mix organic residues and minerals

in the soil. Many soils in the survey area show evidence of earthworm activities.

Plants moderate the temperature of soils by providing shade and slowing down evaporation from the soil surface. They also have an affect on the moisture contained in the soil according to the amount they use in growth. Plants and their residues affect the loss of soil from the surface through erosion and the amount of soil accumulated through soil blowing and flooding.

Relief

Relief, or lay of the land, influences the formation of soils through its effect on drainage, erosion, soil temperature, and plant cover. In the survey area the degree of soil formation depends to a large extent on the amount of water that enters the soil.

Runoff is excessive where slopes are moderate and steep. Most profiles of soils that have steep slopes are less developed than profiles of soils that have gentle slopes, because less water percolates through them. Water drains away slowly on some level, low-lying soils. Excessive amounts of standing water interfere with free movement of air into the soil, and this affects plants and micro-organisms. The deeper soils in the survey area are nearly level and gently sloping.

Erosion can carry away the soil material that forms on steep slopes, and this material can be deposited in nearly level and gently sloping areas. Steepness and direction of slope influence soil and air temperatures. A difference in temperature can result in a change in the amount of moisture that is in the soils, which in turn affects the vegetation on the soils. In the survey area the soils that have north-facing slopes remain cold and frozen longer than those that have south-facing slopes.

Steep soils produce less vegetation than soils that have gentle slopes, because the amount of available soil moisture is less. This limits the amount of residue that can be used for supplying organic matter to the soils that have steep slopes.

Time

The length of time required for the formation of distinct soil horizons depends largely on the other factors of soil formation. Because of the differences in parent material, in relief, or in both of these factors, some soils have more distinct horizons than others.

Ivan and Kennebec soils, which formed in alluvium, lack distinct horizons because new material is deposited by stream overflow. Distinct soil horizons are not likely to develop, even over a long period of time. Sloping soils, such as those in the Clime series, lack distinct horizons because of high runoff and the removal of material by erosion. In contrast, the Irwin soils, which are on stable landscapes, have been exposed to soil-forming processes for a long time and have distinct horizons. Some kinds of parent rock are so resistant to weathering that soil formation is very slow, even though other conditions are favorable. The Sogn soils, which formed over limestone, are an example of slowly formed soils.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation (*3*). First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

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

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*11*, *13*).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 7, the soil series of the survey area are placed in three categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this, the Entisols and Histosols, occur in many different climates. Each order is named with a word of three or four syllables ending in *sol* (Ent-i-sol). Entisols and Mollisols are the only orders in the survey area.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

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

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

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The

TABLE 7.—*Classification of soil series*

Series	Family	Subgroup	Order
Benfield	Fine, mixed, mesic	Udic Argiustolls	Mollisols.
Carr	Coarse-loamy, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Chase	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Clime	Fine, mixed, mesic	Udic Haplustolls	Mollisols.
Dwight	Fine, montmorillonitic, mesic	Typic Natrustolls	Mollisols.
Elmont	Fine-silty, mixed, mesic	Typic Argiudolls	Mollisols.
Eudora	Coarse-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Florence [1]	Clayey-skeletal, montmorillonitic, mesic	Udic Argiustolls	Mollisols.
Geary	Fine-silty, mixed, mesic	Udic Argiustolls	Mollisols.
Haynie	Coarse-silty, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Irwin [2]	Fine, mixed, mesic	Pachic Argiustolls	Mollisols.
Ivan	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kahola	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kenesaw [1]	Coarse-silty, mixed, mesic	Typic Haplustolls	Mollisols.
Kennebec [1]	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Mayberry	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Muir	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Reading	Fine, mixed, mesic	Typic Argiudolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Smolan [2]	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Sutphen	Fine, montmorillonitic, mesic	Udertic Haplustolls	Mollisols.
Tully	Fine, mixed, mesic	Pachic Argiustolls	Mollisols.
Wymore	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.

[1] Soils that are placed in the Florence, Kennebec, and Kenesaw series in this survey are taxadjuncts to those series. The Florence soils are dominantly less than 40 inches to a lithic contact. The Kennebec soils are about one reaction class less acid than is within the range defined for the series. These differences do not change the classification of the Florence and Kennebec soils. Kenesaw soils are leached of carbonates to a depth of more than 35 inches. They are classified as Udic Haplustolls rather than the typical series classification of Typic Haplustolls.

[2] The eroded phases of the Irwin and Smolan series are taxadjuncts because they have a mollic epipedon that is less than 20 inches thick. They are classified as Udic Argiustolls rather than the normal phase classification of Pachic Argiustolls.

features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. The great group is not shown separately in table 7, because it is the last word in the name of the subgroup.

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Udifluvents (a typical Udifluvent).

FAMILY. Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used to differentiate families. An example is the coarse-loamy, mixed, calcareous, mesic family of Typic Udifluvents.

General Nature of the Survey Area

This section gives general information about Riley County and part of Geary County. It describes the physiography and drainage, climate, natural resources, farming and ranching, and community facilities and industries of the county.

Physiography and Drainage

Riley County is in the Central Great Plains Winter Wheat and Range land resource region. This region has been further divided into major land resource areas. The western part of the county is in the Central Loess Plains resource area, and the eastern part is in the Bluestem Hills resource area (*2*).

The difference in elevation between the highest and lowest points on the landscape in Riley County is about 560 feet. The lowest point, approximately 965 feet above sea level, is the surface of the water of the Kansas River east of Zeandale. The highest point, approximately 1,525 feet, is near the southeast corner of the county.

Three distinct topographic types are represented in the county. One type is represented by the gently sloping and sloping high uplands in the western part. This area is in the Central Loess Plains major land resource area, and it generally is 1,250 to 1,450 feet above sea level. The soils are deep and are underlain by limestone strata that generally dip slightly to the west-northwest.

The second topographic type is represented by the alluvial floors of the large creeks and river valleys. The

valleys generally range from ¼ mile to 4 miles in width. The soils are deep and nearly level, except for a few old oxbow lakes in the Kansas River valley and a few low terrace escarpments in river and creek valleys.

The third type is the area between stream valleys and high uplands. It includes the Bluestem Hills major land resource area. This is the most dissected area in the county, and some drainageways occupy narrow canyons. The soils range from shallow to deep and from sloping to steep, and there are many outcrops and escarpments of shale and limestone.

Most of Riley County is drained by the Kansas River and its tributaries. The southern part of the county is drained by McDowell and Deep Creeks, which flow into the Kansas River. The southwestern part is drained mainly by the Republican River and Sevenmile Creek. Wildcat Creek drains most of the west-central part, and the Big Blue River drains all of the eastern part. The northwestern area is drained by Fancy Creek and its smaller tributaries, which flow into the Big Blue River. An area of about 10 square miles in the southeastern part of the county is drained by the Neosho River. An intricate system of intermittent drainageways drains all areas of the county into these major tributaries. The larger streams in the area are nearly stable in grade, and their flood plains are well developed. The smaller streams and intermittent drainageways have steeper gradients.

Climate [10]

Riley County has a continental climate that is characterized by warm to hot summers, cold winters, abundant sunshine, moderate winds, low to moderate humidity, and a pronounced peak in rainfall late in spring and during the first half of summer. The county is in the region of prevailing westerlies, where transient low-pressure disturbances and intrusions of cold polar air are common. Both of these influences contribute to the changeable weather pattern that is typical of Kansas and the Midwestern States. Table 8 shows temperature and precipitation data for Riley County, and table 9 gives the probabilities of freezing temperatures in the central part of the county.

The Gulf of Mexico is the principal source of moisture for precipitation in Kansas (*5*). Because the flow of moist air from the Gulf is more frequent over the eastern part of Kansas than over the western part, the average annual precipitation in the State decreases about 1 inch for each 17 miles of distance from east to west. Consequently, rainfall in Riley County and part of Geary County and elsewhere in eastern Kansas is considerably greater than it is along the western border of the State.

A large part of the annual precipitation falls during the crop growing season, and this is of great significance to farming and ranching. The average precipitation is 31.6 inches per year, and three-fourths of this falls during the 6-month period from April through September. There is a distinct peak of rainfall in spring and during the first half of summer, when showers and thundershowers make up most of the precipitation. On the average, thunderstorms occur on about 55 days each year in Riley County. Some of the thunderstorms are violent and produce heavy rainfall, large hailstones, and tornadoes. Damage from these storms, however, generally is local in extent and occurs in a variable and spotted pattern.

Rainfall gradually declines after the peak in the May-July period and drops to an average of 0.8 inch in January. Because the climate is continental, winter is the dry season. Less than 3 inches of precipitation falls during the period from December through February. Since 1858, the annual precipitation at Manhattan has ranged from 15.13 inches in 1860 to 60.38 inches in 1951. A lack of precipitation affects the production of crops and grasses in some years, and droughts of several years duration occur at irregular intervals. Drought was very serious in Riley County and part of Geary County and elsewhere in eastern Kansas from 1952 through 1956.

Snowfall is light in most years; it averages about 19 inches annually. February has an average of 4.8 inches and generally is the month that has the heaviest snowfall. Total snowfall for a winter has been as high as 56 inches, but generally no more than 30 inches falls during the cold season. Ordinarily, snow stays on the ground for only a few days.

Daily and annual temperature ranges are relatively large and show the effects of the continental climate. The transition from cold to warm seasons is rapid. The mean monthly temperature is 43.5° F. in March, whereas it is 55° in April. The change is even greater between the average of 58° in October and the 44° in November. Temperature extremes at Manhattan for the entire period of record are −32° and 116°. In most years the temperature falls below zero at least once, and a maximum of 100° or above occurs at least once in nearly every summer. The average freeze-free period is 178 days and extends from April 22 to October 17 (*4*). There is little freeze damage to crops in most years.

Prevailing surface winds in the survey area are southerly. Winds generally are light to moderate in all seasons, although they are strong at times. The windiest period is in March and April, when the average windspeed is about 13 miles per hour.

The climate generally is favorable for farming and ranching in the survey area. There is light precipitation in some years, but the length of the growing season, the seasonal distribution of precipitation, and the percentage of possible sunshine all contribute to a high level of crop production in the survey area.

Natural Resources

One of the most valuable natural resources in the survey area is the ground water that is available in the valleys of the Kansas, Republican, and Big Blue Rivers. This water can be used for irrigation, for watering livestock, and for domestic and municipal uses.

Sand and gravel are available in abandoned river channels, on some of the flood plains, and in the present stream channels of the Kansas and Republican Rivers. Chert gravel is available in some of the smaller streams that drain through the cherty limestone hills.

[10] By MERLE J. BROWN, climatologist for Kansas, National Weather Service, U.S. Department of Commerce, Manhattan.

TABLE 8.—*Temperature and precipitation at Manhattan*

Month	Temperature				Precipitation				
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with—		Average total [1]	One year in 10 will have—		Days with snow cover of 1 inch or more [1]	Average depth of snow on days with snow cover [1]
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	39.6	18.0	60	0	0.80	0.13	1.68	2	2
February	45.4	22.4	65	5	1.12	.28	2.23	2	2
March	55.9	30.9	77	12	1.56	.21	3.40	2	2
April	67.7	42.6	84	28	2.73	1.11	5.13	[2]	3
May	76.5	52.7	90	39	4.34	1.75	7.99	0	0
June	86.5	62.8	100	52	4.76	1.56	7.96	0	0
July	92.6	67.1	106	57	4.38	.85	7.53	0	0
August	91.5	65.7	105	55	3.87	.80	8.79	0	0
September	83.5	57.1	98	41	3.48	.79	7.48	0	0
October	71.4	45.0	88	30	2.30	.68	4.01	[2]	2
November	55.9	31.5	73	15	1.42	.07	3.53	1	2
December	42.9	21.6	62	6	.88	.15	2.23	2	2
Year	67.5	43.1	[3] 105	[4] −10	31.64	21.81	41.17	9	2

[1] Data for period 1898–1960.
[2] Less than 0.5 day.
[3] Average annual highest temperature, 1894–1967.
[4] Average annual lowest temperature, 1894–1967.

TABLE 9.—*Probabilities of last freezing temperatures in spring and first in fall in central part of Riley County*

Probability	Dates for given probability at a temperature of—				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	March 31	April 6	April 11	April 23	May 7
2 years in 10 later than	March 25	April 1	April 6	April 18	May 2
5 years in 10 later than	March 13	March 22	March 28	April 8	April 22
Fall:					
1 year in 10 earlier than	November 9	October 31	October 20	October 13	October 3
2 years in 10 earlier than	November 15	November 5	October 24	October 18	October 7
5 years in 10 earlier than	November 27	November 16	November 3	October 27	October 17

Limestone is present in large quantity. The limestone can be used as a source of crushed rock, as agricultural lime, and for manufacturing lime cement and rock wool. Some limestone can be used as building stone.

Some clay shales are suitable for manufacturing brick and tile. A small amount of crude petroleum is produced in the southeastern part of Riley County.

Farming and Ranching

Farms and ranches in Riley County are of a general type. Most farms have more than one livestock or crop enterprise. A farmer who raises cash crops generally has a few chickens and cows. A dairy farmer generally raises his own replacement cows and most of the feed for his herd. A rancher with beef cattle generally has some cropland, and he finishes his cattle for market in his own feedlot.

The amount of land in the survey area used for farming and ranching has decreased significantly during the past 30 years as a result of the expansion of Fort Riley Military Reservation, the construction of Tuttle Creek Reservoir and nearby residential and recreational areas, and the expansion of the city of Manhattan. In 1968, an estimated 270,000 acres in the county was used as farmland and ranchland.

In recent years, slightly more than one-half of the farm income has come from livestock products. About 40 percent of the income has come from the production of field crops, and about 10 percent from hay crops.

Raising beef cattle is the largest livestock enterprise in the county in amount of income produced. Pork production ranks second, but total income from pork is less than one-half the amount derived from beef. Milk from dairy cattle ranks a close third. Some farm income is from the sale of eggs and broilers, turkeys, and sheep and wool.

Following is listed the number of livestock on farms and ranches in Riley County in 1958, 1963, and 1968, as estimated by the Kansas State Board of Agriculture (*7*, *8*, *9*). The number of beef cattle produced in 1958, 1963, and 1968 was 37,700, 42,200, and 41,200, respectively; milk cows—4,300, 3,800, and 2,800; hogs—16,000, 24,500, and 23,700; sheep and lambs—3,450, 5,700, and 1,100; and chickens—151,000, 107,000, and 85,000.

According to data compiled in 1968, grain sorghum is the field crop producing the highest income in Riley County, and wheat is a close second. The value of corn raised for grain is only about one-fourth the value of grain sorghum produced. Some farm income comes from soybeans and minor acreages of oats, barley, and rye. The value of tame hay and alfalfa hay almost equals that of grain sorghum. Much of the corn and sorghum produced in the county is used for silage.

The acreage of principal crops harvested in Riley County also was estimated by the Kansas State Board of Agriculture. The acres of corn used for grain in 1958, 1963, and 1968 were 29,700, 14,300, and 7,400, respectively; corn used for silage—(no estimate in 1958), 7,500, and 400; sorghum used for grain—16,200, 22,300, 29,000; sorghum used for silage—4,700, 3,600, and 5,000; sorghum used for forage—700, (no estimate in 1963), and 600; wheat—33,000, 32,000, and 33,000; and alfalfa—20,300, 15,800, and 15,000.

Total income from other farm enterprises is small. In 1968 about 35 acres of Irish potatoes, 25 acres of sweet potatoes, and 326,400 pounds of apples were harvested (*7*).

Community Facilities and Industries

Kansas State University, a land-grant institution, is located in Manhattan. Enrollment in 1970 was more than 12,500 students. An area vocational technical school and Manhattan Bible College also are in Manhattan.

The Riley County Historical Society Museum is in Manhattan. It depicts much of the history of the pioneer and of this section of the nation.

Tuttle Creek Reservoir is the major outdoor recreational attraction in the survey area. The lake is bordered by several recreational parks and marinas, all easily accessible over good roads.

Prairie Parkway, a national scenic drive through parts of Riley County, provides a view of the Great North American Prairie. Ozark Frontier, a four-state tourist route, also passes through Manhattan and parts of the county.

Riley County is served by Interstate Highway 70, U.S. Highways No. 24 and No. 77, and State Highways 13, 16, 18, 82, 113, and 177. County and township highway departments maintain a good system of all-weather roads. Bus lines, an airline, and railroads provide passenger and freight services for the Manhattan area.

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Glossary

Alluvial fan. A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly.

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

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

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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

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

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

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

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

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

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

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

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

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

Contour farming. Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

Diversion, or diversion terrace. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

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

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

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

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

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

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

Leaching. The removal of soluble materials from soils or other material by percolating water.

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

Micro-organisms. Forms of life that are either too small to be seen with the unaided eye or are barely discernible.

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

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

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

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

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

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

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

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

Slope. The number of feet of fall per 100 feet of horizontal distance. Expressed in this survey as—

Nearly level	0 to 1 percent.
Gently sloping	1 to 4 percent.
Sloping	4 to 10 percent.
Moderately steep	10 to 30 percent.
Steep	30 percent or more.

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

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

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

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

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

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces

in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

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 sandy, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

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

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. See page 37 for a discussion of the capability groupings. In referring to a range site, a woodland suitability group, or a windbreak suitability group, read the introduction to the section it is in for general information about its management. Other information is given in tables as follows:

Acreage and extent, table 1, page 8.
Predicted yields, table 2, page 39.

Recreational uses, table 4, page 48.
Engineering uses of the soils, tables 5 and 6, pages 52 through 61.

Map symbol	Mapping unit	Page	Capability unit	Range site		Woodland suitability group		Windbreak suitability group	
			Symbol	Name	Page	Number	Page	Symbol	Page
Ad	Alluvial land	9	VIw-1	Loamy Lowland	42	1	44	A	45
Bf	Benfield-Florence complex, 5 to 20 percent slopes	10	VIe-2	Loamy Upland	42	---	--	---	--
	Benfield	--	-----	---------	--	---	--	C	45
	Florence	--	-----	---------	--	---	--	F	46
Bk	Breaks-Alluvial land complex	10	VIe-3	---------	--	---	--	---	--
	Breaks	--	-----	Clay Upland	40	---	--	E	46
	Alluvial land	--	-----	Loamy Lowland	42	---	--	A	45
Ca	Carr-Sarpy complex	12	IIIw-1	--------	--	4	45	H	46
	Carr	--	-----	Sandy Lowland	43	---	--	---	--
	Sarpy	--	-----	Sands	43	---	--	---	--
Ch	Chase silty clay loam	12	IIw-2	Loamy Lowland	42	3	44	A	45
Cs	Clime-Sogn complex, 5 to 20 percent slopes	13	VIe-1	--------	--	---	--	---	--
	Clime	--	-----	Limy Upland	41	---	--	D	46
	Sogn	--	-----	Shallow Limy	43	---	--	G	46
Dr	Dwight-Irwin complex, 1 to 4 percent slopes	15	IIIe-3	--------	--	---	--	E	46
	Dwight	--	-----	Claypan	41	---	--	---	--
	Irwin	--	-----	Clay Upland	41	---	--	---	--
Dw	Dwight-Irwin complex, 1 to 4 percent slopes, eroded	15	IIIe-4	Claypan	41	---	--	E	46
Em	Elmont silt loam, 3 to 8 percent slopes	16	IIIe-5	Loamy Upland	42	---	--	C	45
En	Elmont-Clime complex, 5 to 15 percent slopes	17	VIe-4	--------	--	---	--	---	--
	Elmont	--	-----	Loamy Upland	42	---	--	C	45
	Clime	--	-----	Limy Upland	41	---	--	D	46
Eu	Eudora silt loam	17	I-1	Loamy Lowland	42	3	44	A	45
Ga	Geary silt loam, 1 to 4 percent slopes	19	IIe-3	Loamy Upland	42	---	--	C	45
Ge	Geary silt loam, 4 to 8 percent slopes	19	IIIe-5	Loamy Upland	42	---	--	C	45
Ha	Haynie very fine sandy loam	20	I-1	Loamy Lowland	42	3	44	A	45
Ic	Irwin silty clay loam, 4 to 8 percent slopes	21	IIIe-6	Clay Upland	41	---	--	C	45
Id	Irwin silty clay loam, 4 to 8 percent slopes, eroded	21	IVe-1	Claypan	41	---	--	E	46
Ie	Ivan silty clay loam, 1 to 3 percent slopes	22	IIe-2	Loamy Upland	42	3	44	A	45
Iv	Ivan and Kennebec silt loams	22	IIw-1	Loamy Lowland	42	1	44	A	45
Ka	Kahola silt loam	23	I-1	Loamy Lowland	42	3	44	A	45
Ke	Kenesaw silt loam, 2 to 6 percent slopes	23	IIIe-5	Loamy Upland	42	---	--	C	45
Kf	Kenesaw silt loam, 6 to 10 percent slopes	23	IVe-2	Loamy Upland	42	---	--	C	45
Ma	Mayberry clay loam, 2 to 6 percent slopes	25	IIIe-1	Clay Upland	40	---	--	C	45
Mb	Mayberry clay loam, 2 to 6 percent slopes, eroded	25	IIIe-6	Claypan	41	---	--	E	46
Mu	Muir silt loam	26	I-1	Loamy Lowland	42	3	44	A	45
Rd	Reading silt loam, 0 to 1 percent slopes	27	I-2	Loamy Lowland	42	3	44	A	45
Re	Reading silt loam, 1 to 3 percent slopes	27	IIe-2	Loamy Upland	42	3	44	A	45
Sa	Sarpy loamy fine sand	28	VIe-5	Sands	43	4	45	H	46
Sm	Smolan silt loam, 1 to 4 percent slopes	29	IIe-1	Loamy Upland	42	---	--	C	45
Sn	Smolan silt loam, 4 to 8 percent slopes	29	IIIe-1	Loamy Upland	42	---	--	C	45
So	Smolan silty clay loam, 4 to 8 percent slopes, eroded	29	IIIe-6	Clay Upland	41	---	--	E	46
St	Stony steep land	30	VIIe-1	Breaks	40	---	--	F	46
Su	Sutphen silty clay	31	IIIw-2	Clay Lowland	40	2	44	B	45
Ts	Tully silty clay loam, 1 to 4 percent slopes	33	IIe-1	Loamy Upland	42	---	--	C	45
Tt	Tully silty clay loam, 1 to 4 percent slopes, eroded	33	IIIe-2	Clay Upland	41	---	--	E	46
Tu	Tully silty clay loam, 4 to 8 percent slopes	33	IIIe-1	Loamy Upland	42	---	--	C	45
Tv	Tully silty clay loam, 4 to 8 percent slopes, eroded	33	IIIe-6	Clay Upland	41	---	--	E	46
Wm	Wymore silty clay loam, 0 to 1 percent slopes	35	IIs-1	Loamy Upland	42	---	--	C	45
Wn	Wymore silty clay loam, 1 to 4 percent slopes	35	IIe-1	Loamy Upland	42	---	--	C	45
Wo	Wymore silty clay loam, 1 to 4 percent slopes, eroded	35	IIIe-2	Clay Upland	41	---	--	E	46
Wr	Wymore silty clay loam, 4 to 8 percent slopes	36	IIIe-1	Loamy Upland	42	---	--	C	45
Ws	Wymore silty clay loam, 4 to 8 percent slopes, eroded	36	IIIe-6	Clay Upland	41	---	--	E	46

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