

SOIL SURVEY OF

Leavenworth and Wyandotte Counties, Kansas



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

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

Major fieldwork for this soil survey was completed in the period 1957-71. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service and the Kansas Agricultural Experiment Station. It is part of the technical assistance furnished to the Leavenworth and Wyandotte Counties Soil Conservation Districts.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an over-

lay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the section "Crops and Pasture."

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

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

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the section "Town and Country Planning."

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

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

Newcomers in Leavenworth and Wyandotte Counties may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Additional Facts about the Counties."

Contents

	Page		Page
How this survey was made	1	Pawnee series	28
General soil map	2	Sarpy series	30
Nearly level soils formed in alluvium; on flood plains and terraces	2	Sharpsburg series	30
1. Kennebec-Bremer-Wabash associa- tion	2	Shelby series	31
2. Onawa-Haynie-Eudora association ..	3	Sibleyville series	33
Gently sloping to steep soils formed in loess; on uplands	4	Sogn series	33
3. Knox-Ladoga association	5	Vinland series	33
4. Marshall-Sharpburg association ..	5	Wabash series	34
Gently sloping to strongly sloping soils formed in loess and glacial till; on uplands	5	Welda series	35
5. Sharpburg-Shelby association	6	Zook series	36
6. Grundy-Pawnee-Shelby association ..	7	Use and management of the soils	36
Nearly level to steep soils formed in loess and in material weathered from shale and sandstone; on uplands	8	Crops and pasture	37
7. Martin-Grundy-Haig association	8	Capability grouping	37
8. Elmont-Basehor-Vinland association	8	Predicted yields	38
Sloping to steep soils formed in silty and loamy loess and in material weathered from shale and limestone; on uplands	9	Woodland	39
9. Welda-Konawa association	9	Wildlife	42
10. Gosport-Sogn association	9	Recreation	45
Descriptions of the soils	10	Engineering	56
Alluvial land	10	Engineering classification systems	56
Armster series	10	Engineering properties	57
Basehor series	12	Engineering interpretations	58
Bremer series	13	Test data	58
Elmont series	14	Town and country planning	59
Eudora series	15	Limitations for community development	59
Gosport series	16	Selection of shrubs and trees	64
Grundy series	17	Suitability for orchards, gardens, and lawns	64
Gymer series	18	Formation and classification of the soils	71
Haig series	19	Factors of soil formation	71
Haynie series	19	Parent material	72
Judson series	20	Climate	72
Kennebec series	20	Plant and animal life	73
Knox series	21	Relief	73
Konawa series	23	Time	73
Ladoga series	24	Classification of the soils	73
Marshall series	25	Additional facts about the counties	74
Martin series	25	Physiography, relief, and drainage	75
Onawa series	26	Climate	75
Oska series	28	Water supply	76
		Farming	77
		Industry and natural resources	77
		Transportation and markets	77
		Literature cited	77
		Glossary	78
		Guide to mapping units	Following
			80

Cover: Picnic areas, shelters, and parking lot
on Shelby loam.

Issued February 1977

SOIL SURVEY OF LEAVENWORTH AND WYANDOTTE COUNTIES, KANSAS

BY LARRY D. ZAVESKY AND WILLIAM C. BOATRIGT,
SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE KANSAS AGRICULTURAL EXPERIMENT STATION¹

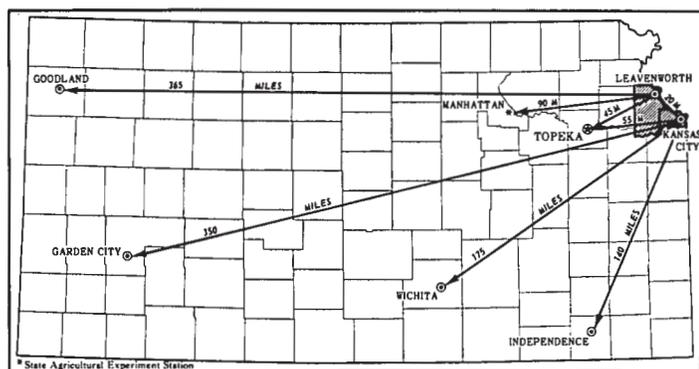


Figure 1.—Location of Leavenworth and Wyandotte Counties in Kansas.

LEAVENWORTH and WYANDOTTE COUNTIES are in the northeastern part of Kansas (fig. 1). The total area is 631 square miles, or 403,840 acres.

Leavenworth County is adjacent to the Missouri River on the east and to the Kansas River on the south. It is bordered on the north by Atchison County and on the west by Jefferson and Douglas Counties. Leavenworth, on the loess hills adjacent to the Missouri River, is the county seat. The total area of the county is 472 square miles, or 302,080 acres.

Wyandotte County is adjacent to the Missouri River on the northwest and is bordered by Leavenworth County on the north and west. It is bordered on the south by the Kansas River and Johnson County. Kansas City, on the loess hills of east Wyandotte County, is the county seat. The total area of the county is 159 square miles, or 101,760 acres.

About 175,000 acres in the survey area is used for cash farming, and most of this acreage is in Leavenworth County. The main crops are corn, grain sorghum, soybeans, and small grain. Alfalfa, tame grass pasture, and some of the grain are used for feed in the production of beef and dairy products. Raising poultry for eggs is also important. Crops grow well because most rainfall comes during the growing season. The moderately steep and steep soils in the

counties are in native timber, which is dominantly oak and hickory, and in tame grass pasture.

Urban growth is very rapid in Wyandotte County. In 1965, about 40 percent of the county was under city and urban development. In 1972, the population of Wyandotte County was 189,491, of which 89 percent was in Kansas City. In 1972, the population of Leavenworth County was 47,437, of which 63 percent was in Leavenworth. Many commute from Leavenworth County and from the western part of Wyandotte County to work in Kansas City.

Most of the cultivated soils in these counties are suited to the crops commonly grown, but many are severely limited for urban use. The soils near the Kansas River could be used more extensively for truck farming if adequate labor were available. In many places wooded areas and ponds are suitable for recreational development.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Leavenworth and Wyandotte Counties, where they are located, and how they can be used. The soil scientists went into the counties 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

¹ WILLIAM CARTER and EDWARD L. SWIERCINSKY, soil scientists, Soil Conservation Service, assisted in making this survey.

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. Basehor and Welda, 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, Grundy silty clay loam, 3 to 7 percent slopes, is one of several phases within the Grundy 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. One such kind of mapping unit, a soil complex, is shown on the soil map of Leavenworth and Wyandotte Counties.

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. Gosport-Sogn complex is an example.

In most areas surveyed there are places where the soil material is so rocky, so variable, or so severely eroded 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 Leavenworth and Wyandotte Counties.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have

been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland and rangeland, and engineers.

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

General Soil Map

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

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

The 10 soil associations in this survey have been grouped into five general kinds of landscapes for broad interpretative purposes. Each of the broad groups and their soil associations are described on the following pages.

Nearly Level Soils Formed in Alluvium; on Flood Plains and Terraces

These nearly level soils make up about 18 percent of the survey area. They are on flood plains and terraces along the major streams and are frequently to occasionally flooded. Most of the acreage is cultivated to corn, grain sorghum, soybeans, and small grain. Part of it is irrigated. The principal management needs are controlling flooding, improving drainage, and maintaining fertility and tilth. Soil blowing is a hazard on some of these soils. Possible flooding, permeability, and drainage are the main limitations for urban use.

1. Kennebec-Bremer-Wabash association

Deep, moderately well drained to very poorly drained, nearly level soils that have a silt loam, silty clay loam, and silty clay subsoil; on flood plains and low terraces of creeks

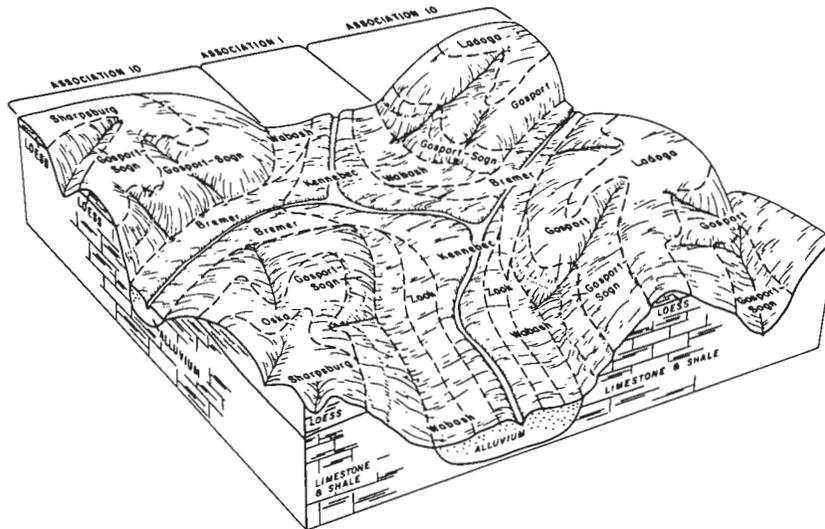


Figure 2.—Pattern of soils and parent material in associations 1 and 10, along Stranger Creek in Leavenworth County.

This association consists of nearly level soils on low bottom land, on high bottom land where backwater areas are adjacent to the upland, and on low terraces along tributary streams of the Kansas and Missouri Rivers.

This association (fig. 2) makes up about 8 percent of the counties. It is about 35 percent Kennebec soils, 30 percent Bremer soils, 15 percent Wabash soils, and 20 percent less extensive soils.

Kennebec soils are on low bottom land that is subject to frequent flooding. They are nearly level and moderately well drained. They have a silt loam surface layer that is very dark brown in the upper 20 inches and very dark grayish brown in the lower 25 inches. The underlying material is dark grayish-brown light silty clay loam.

Bremer soils are nearly level, somewhat poorly drained soils on low terraces that are rarely flooded. They have a black silty clay loam surface layer about 9 inches thick. The subsoil is about 41 inches thick. It is very dark-gray silty clay in the upper part and grayish-brown silty clay loam in the lower part. It is underlain by grayish-brown and yellowish-brown silty clay loam.

Wabash soils are nearly level, very poorly drained soils in backwater areas on the high bottom land near Stranger Creek. They formed in clayey alluvium. They are subject to occasional flooding. They have a black silty clay surface layer about 19 inches thick. The subsoil is silty clay about 41 inches thick. It is very dark gray in the upper part and dark gray in the lower part.

Of lesser extent in this association are Zook and Martin soils and Alluvial land. The nearly level Zook soils are between Kennebec and Wabash soils and slope toward Wabash soils. They make up about 12 percent of the association. Martin soils are sloping and are adjacent to uplands. Alluvial land is loamy and is frequently flooded. It occupies the steep banks along perennial streams.

Most of the acreage is cultivated. Kennebec, Bremer, and Zook soils are suited to most crops grown in

the counties. Wabash soils are best suited to grain sorghum, soybeans, and tame grasses. The soils that are subject to flooding are not suited to alfalfa. All the soils, particularly Wabash soils, are suited to trees, especially cottonwoods. All are high in natural fertility. The main concerns in management are controlling flooding, improving drainage, and maintaining fertility and tilth. The main limitation for urban use on Kennebec, Wabash, and Zook soils is flooding. On Bremer soils it is permeability.

2. Onawa-Haynie-Eudora association

Deep, well drained and somewhat poorly drained, nearly level soils that have a loamy and clayey surface layer; on flood plains of rivers

This association consists of nearly level soils along abandoned stream channels and gently undulating soils adjacent to the Kansas and Missouri Rivers. Spots of sand occur throughout this association.

This association (fig. 3) makes up about 10 percent of the counties. It is about 30 percent Onawa soils, 25 percent Haynie soils, 17 percent Eudora soils, and 28 percent less extensive soils and water areas.

Onawa soils are nearly level, calcareous, and somewhat poorly drained soils on flat to slightly depressional flood plains. They formed in clayey alluvium underlain by loamy alluvium. They are mainly on bottom land along the Missouri River and are subject to occasional flooding. The surface layer is very dark gray silty clay loam about 6 inches thick. In some areas, it ranges from fine sandy loam to silt loam to a depth of about 9 inches because some of these soils were covered by sandy and loamy alluvium during a major flood. The next layer is dark-gray and very dark gray silty clay about 19 inches thick. It is underlain by grayish-brown coarse silt loam.

Haynie soils are nearly level, calcareous, well-drained soils on low bottom land adjacent to the rivers or on slightly raised areas within the high bottom land. They are occasionally flooded. Their surface layer is about 8 inches of very dark grayish-

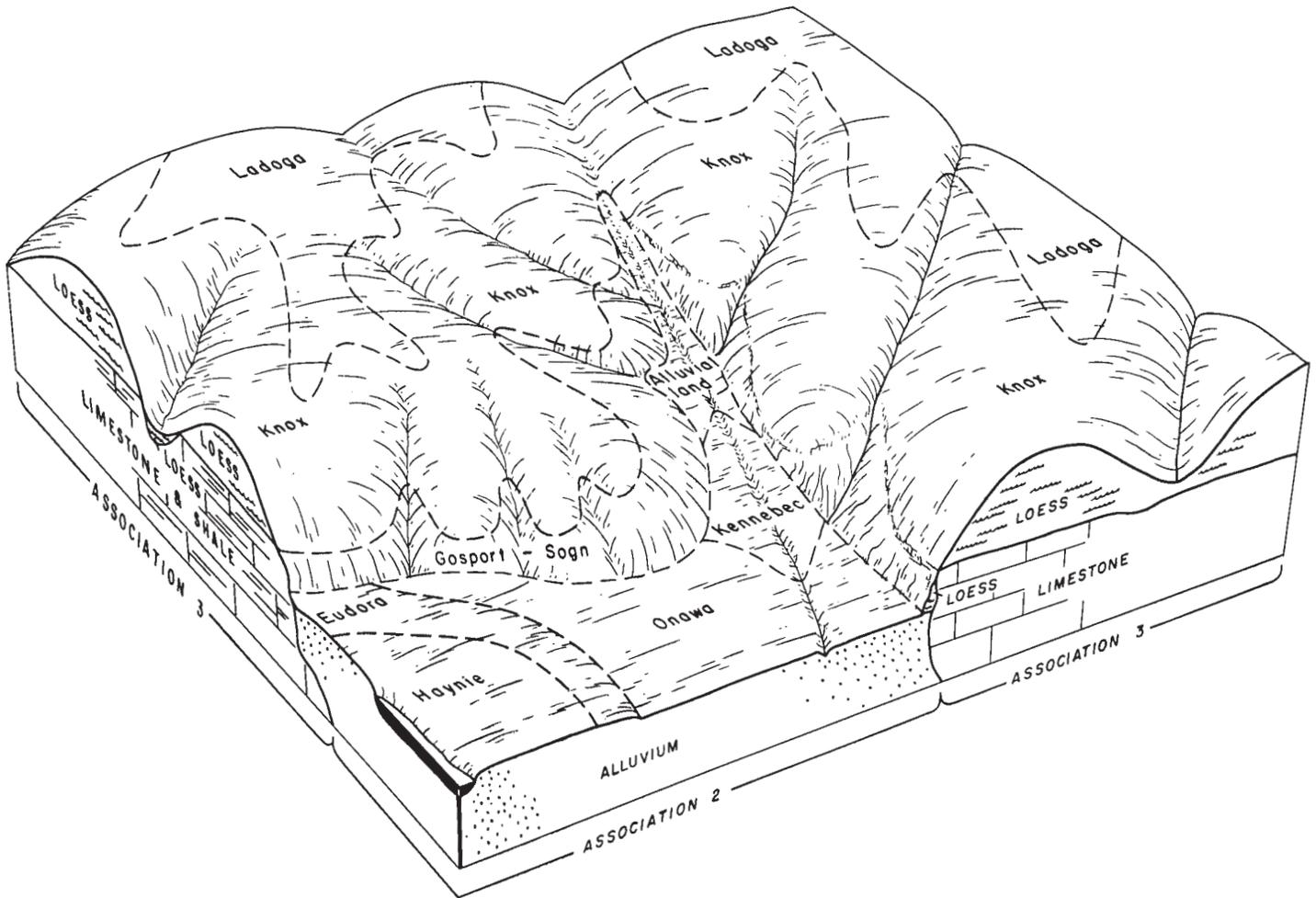


Figure 3.—Pattern of soils and parent material in associations 2 and 3. Loess bluffs in the northern part of Wyandotte County, adjacent to the Missouri River.

brown silt loam. The underlying material is dark grayish-brown silt loam and very fine sandy loam.

Eudora soils are nearly level, well-drained soils on the high bottom land along the Kansas River. They are rarely flooded. They are slightly acid to moderately alkaline throughout. The surface layer is variable and ranges from loamy very fine sand to silt loam because it was covered by sandy and loamy alluvium during a major flood. It is about 24 inches thick. The upper 9 inches is dark grayish-brown very fine sandy loam, the next 3 inches is grayish-brown loamy very fine sand, and the lower 12 inches is very dark grayish-brown coarse silt loam. Below this is about 10 inches of dark-brown coarse silt loam. The underlying material is very fine sandy loam that grades to loamy fine sand below a depth of 65 inches.

About 7 percent of this association is Judson, Kennebec, and Sarpy soils and 21 percent is the Kansas and Missouri Rivers. Kennebec soils are nearly level and are adjacent to uplands where tributaries enter the river valley. Judson soils are nearly level and are on low terraces adjacent to uplands. Sarpy soils are sandy throughout, are nearly level and gently undulating, and are adjacent to the river.

Except for the industrial areas, the soils in this association are mostly cultivated. Areas adjacent to the river are generally wooded. Corn, soybeans, grain sorghum, and small grain are the main crops. Eudora and Haynie soils are well suited to vegetable farming and can be irrigated from wells or the river. Both are subject to soil blowing. Onawa and Eudora soils have high natural fertility. Haynie soils have low organic-matter content and medium fertility. The main concerns in management are controlling soil blowing and maintaining organic-matter content and fertility. The main limitations for urban use are possible flooding and drainage on Onawa soils.

Gently Sloping to Steep Soils Formed in Loess; on Uplands

These gently sloping to steep soils make up about 18 percent of the survey area. They are on loess-covered hills adjacent to the Missouri and Kansas Rivers. More than half the acreage is cultivated. The rest is in hay and pasture and native timber. Corn, grain sorghum, soybeans, and small grain are the

principal crops grown on the gently sloping to sloping soils. Pasture grasses, hay, and timber are grown on the steeper soils. Some areas are used for truck gardens and orchards. The principal management needs are controlling soil erosion, reducing runoff, and maintaining fertility. Slope and permeability are the main limitations for urban use.

3. *Knox-Ladoga association*

Deep, well drained and moderately well drained, sloping to steep soils that have a silty clay loam and silty clay subsoil

This soil association consists of sloping to steep soils on the dissected bluffs of the Missouri and Kansas Rivers. These soils formed in loess. Adjacent to the rivers the soils are steep and there are many outcrops of limestone.

This association makes up about 15 percent of the counties, and most of it is in Wyandotte County. It is about 51 percent Knox soils, 25 percent Ladoga soils, and 24 percent less extensive soils.

Knox soils are strongly sloping to steep, well-drained soils that have mainly convex and concave slopes. They are medium acid or slightly acid throughout. They have a surface layer of dark-brown silt loam about 6 inches thick. The subsoil is dark yellowish-brown silty clay loam. The underlying material is yellowish-brown silt loam or light silty clay loam.

Ladoga soils are sloping, moderately well drained soils on ridgetops. They are strongly acid to slightly acid. Their surface layer is very dark grayish-brown silt loam about 7 inches thick. The subsoil is dark-brown or brown heavy silty clay loam and silty clay. The underlying material is grayish-brown silty clay loam.

Of lesser extent in this association are Armster, Judson, Kennebec, Marshall, Sogn, and Welda soils and Alluvial land. Armster and Welda soils are sloping to moderately steep and are downslope from Ladoga soils. Judson and Kennebec soils are nearly level and are along drainageways. Kennebec soils are subject to frequent flooding. Marshall soils are gently sloping and are on ridgetops above Knox soils. The shallow Sogn soils and associated limestone outcrops are common on the side slopes adjacent to the streams and rivers. Alluvial land is loamy and is frequently flooded. It occupies the banks and channels of streams.

About 60 percent of the acreage is cleared. The rest is in native timber. The sloping soils are well suited to small grain, grain sorghum, corn, and soybeans. Hay and tame pasture also grow well. The moderately steep Knox soils are well suited to orchards and berries. Sogn soils are not suited to cultivated crops. The main concerns in management are controlling erosion, reducing runoff, and maintaining organic-matter content and fertility. Management is needed to improve the stands of timber and maintain a vigorous stand of tame grass. The main limitation for urban use on Knox soils is the slope. On Ladoga soils it is permeability, and on Sogn soils it is slope and shallowness over rock.

4. *Marshall-Sharpsburg association*

Deep, well drained and moderately well drained, gently sloping to moderately steep soils that have a silty clay loam subsoil

This soil association consists of gently sloping to moderately steep soils on the rolling loess hills below the Oread Limestone escarpment northwest of Leavenworth.

This association makes up about 3 percent of the counties. It is about 41 percent Marshall soils, 35 percent Sharpsburg soils, and 24 percent less extensive soils.

Marshall soils are gently sloping to moderately steep, well-drained soils on the sides and tops of ridges and on concave foot slopes. The surface layer is slightly acid and is about 18 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The subsoil is brown or dark-brown silty clay loam in the upper part and yellowish brown in the lower part. The underlying material is mottled yellowish brown silt loam.

Sharpsburg soils are gently sloping and sloping, moderately well drained soils on the concave sides and tops of ridges. They are medium acid or slightly acid throughout. The surface layer is about 15 inches thick. It is very dark grayish brown in the upper part and dark brown and very dark grayish brown in the lower part. The subsoil is silty clay loam. It is dark brown or brown in the upper part and mottled yellowish brown in the lower part. The underlying material is mottled yellowish-brown light silty clay loam.

Of lesser extent in this association are Bremer, Judson, Kennebec, and Knox soils and Alluvial land. Judson soils are nearly level and are on foot slopes and low terraces. Bremer and Kennebec soils are nearly level and are along creeks. Kennebec soils are on low bottoms that are subject to frequent flooding, and Bremer soils are on low terraces. Knox soils are gently sloping to moderately steep and are on dissected loess hills adjacent to the Missouri River. Alluvial land is loamy and is frequently flooded. It occupies banks and channels of streams.

Nearly all the acreage is cultivated. The soils are well suited to corn, soybeans, and grain sorghum. The gently sloping and sloping soils are also well suited to truck gardens. All are suited to orchards. All have high natural fertility and high available water capacity and are easily worked. The main concerns in management are controlling erosion, reducing runoff, and maintaining fertility. The main limitations for urban use are the unfavorable slope and permeability of Sharpsburg soils. Flooding and wetness limit the use of Bremer and Kennebec soils.

Gently Sloping to Strongly Sloping Soils Formed in Loess and Glacial Till; on Uplands

These gently sloping to strongly sloping soils make up about 34 percent of the survey area. They are on loess-till hills and plains. Most of the acreage is cultivated or planted to hay or tame pasture. Corn, soybeans, grain sorghum, and small grain are the principal crops. The main management concerns are

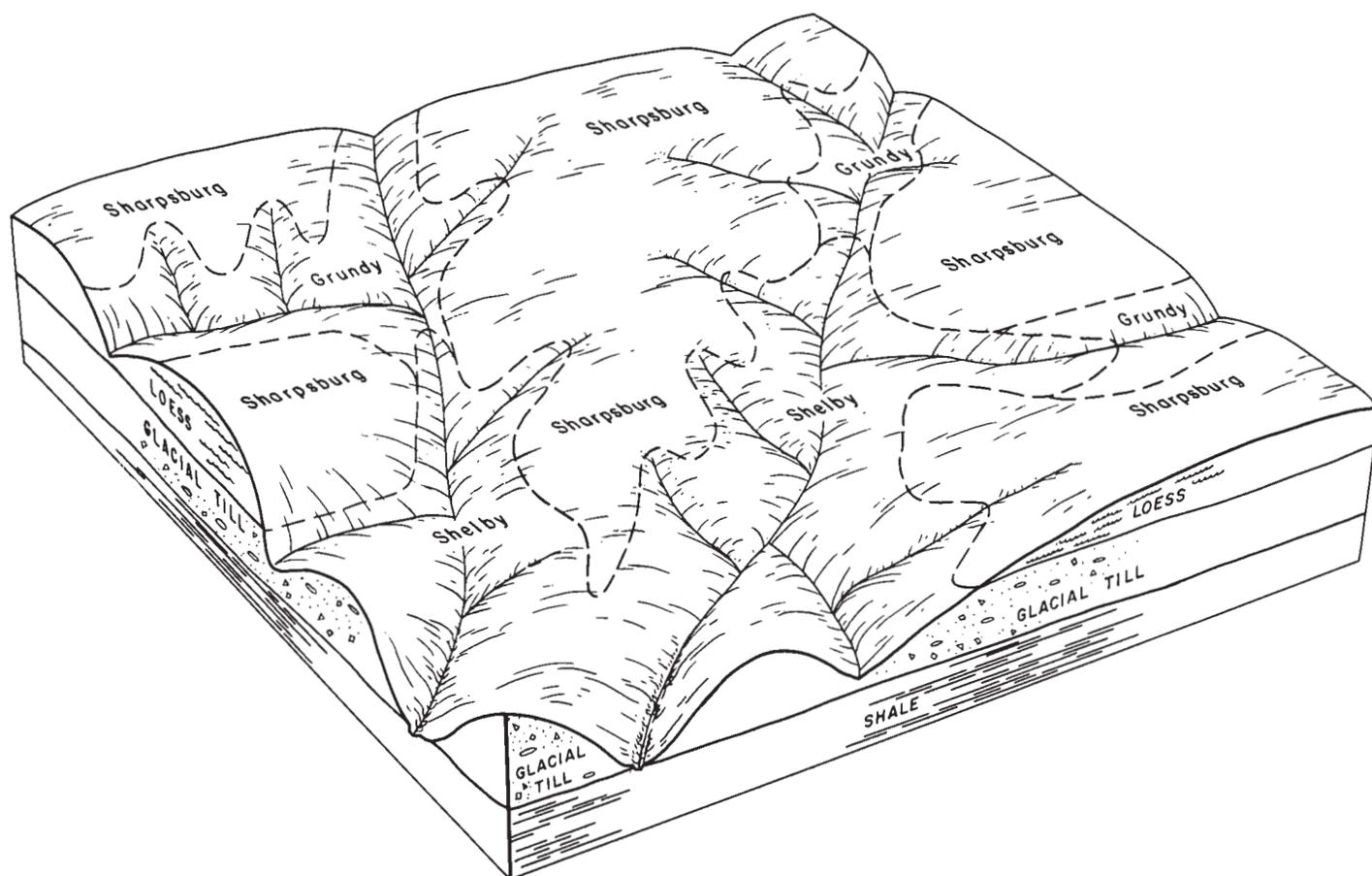


Figure 4.—Pattern of soils and parent material in association 5. A loess-till plain on an upland divide in the western part of Leavenworth County.

controlling soil erosion, reducing runoff, and maintaining fertility. Slope and permeability are the main limitations for urban use.

5. Sharpsburg-Shelby association

Deep, moderately well drained, gently sloping to strongly sloping soils that have a clay loam and silty clay loam subsoil

This soil association consists of gently sloping to strongly sloping soils on the loess-till hills. It is on an upland divide between Stranger Creek and the Missouri River in Leavenworth County and extends into Wyandotte County.

This association (fig. 4) makes up about 16 percent of the counties. It is about 38 percent Sharpsburg soils, 32 percent Shelby soils, and 30 percent less extensive soils.

Sharpsburg soils are gently sloping to sloping, moderately well drained soils on the concave sides and the broad convex tops of ridges. They formed in loess. They are slightly acid. The surface layer is about 15 inches thick. It is very dark grayish brown in the upper part and dark brown and very dark grayish brown in the lower part. The subsoil is silty clay loam. It is dark brown or brown in the upper part and mottled yellowish brown in the lower part. The un-

derlying material is mottled yellowish-brown light silty clay loam.

Shelby soils are gently sloping to strongly sloping, moderately well drained soils that have convex slopes. They are slightly acid in the surface layer and subsoil. They formed in loamy glacial till. The surface layer is about 13 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The subsoil is dark yellowish-brown clay loam that has mottles in the lower part. The underlying material is mottled clay loam that has free calcium carbonate at a depth of 54 inches.

Of lesser extent in this association are Armster, Bremer, Elmont, Grundy, Kennebec, and Pawnee soils and Alluvial land. Armster soils have slopes similar to Shelby soils and are downslope from those soils. Elmont soils are sloping or strongly sloping and are also downslope from Shelby soils. Grundy soils are gently sloping and sloping and are at the heads of drainageways. Kennebec and Bremer soils are nearly level and are along streams. Pawnee soils are gently sloping and sloping and are above Shelby soils. Alluvial land is loamy and is frequently flooded. It occupies the banks and channels of streams.

Most of the acreage is cultivated or planted to hay or tame pasture. The soils are well suited to corn,

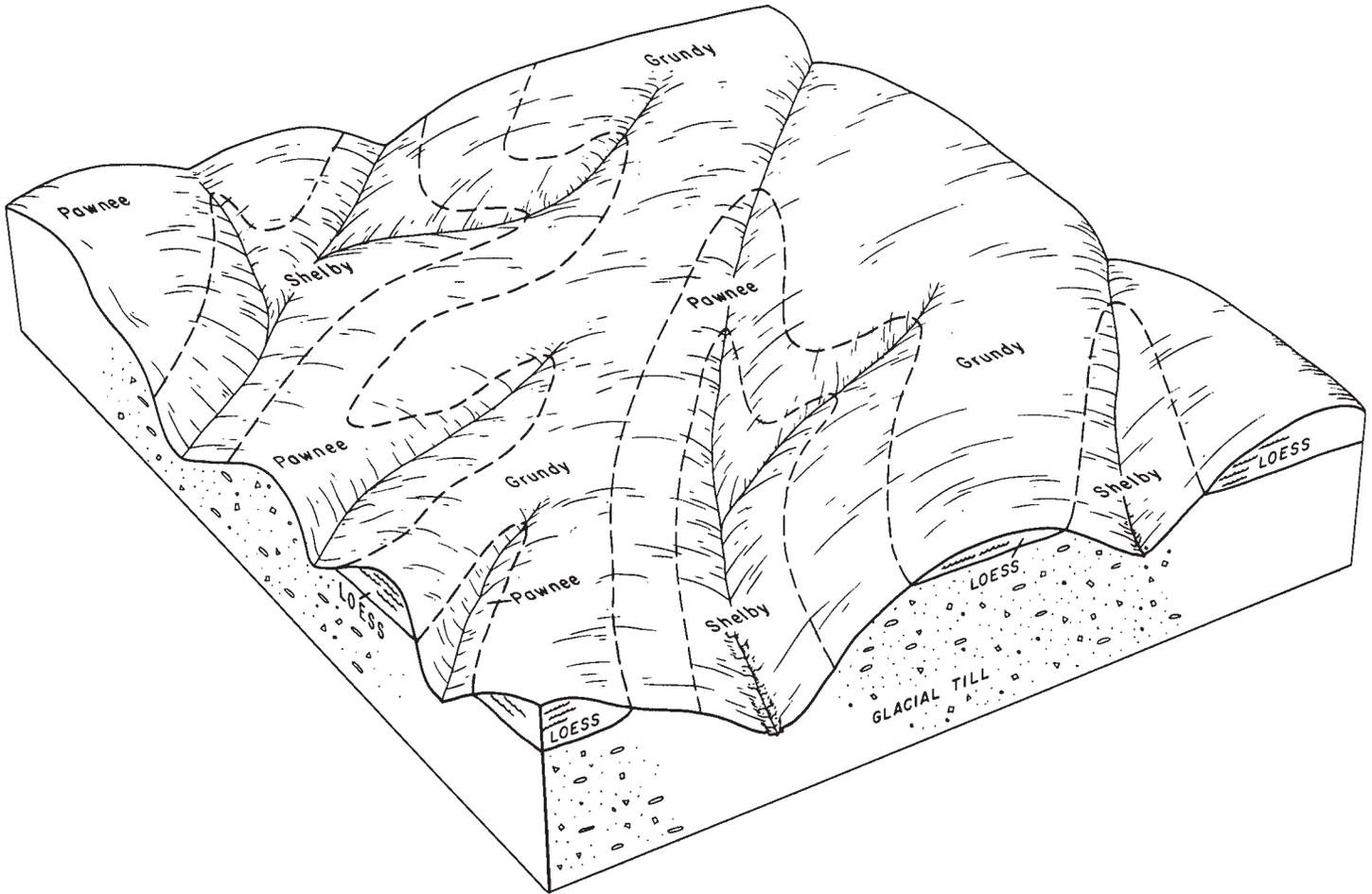


Figure 5.—Pattern of soils and parent material in association 6. A loess-till plain in the western part of Leavenworth County.

soybeans, grain sorghum, and small grain. They have high natural fertility and high available water capacity. The main concerns in management in cultivated areas are controlling erosion, reducing runoff, and maintaining fertility. Tame pasture can be kept vigorous under good grazing management and proper fertilization. The main limitations for urban use are slope and soil permeability.

6. Grundy-Pawnee-Shelby association

Deep, moderately well drained and somewhat poorly drained, gently sloping to strongly sloping soils that have a silty clay and clay loam subsoil

This soil association consists of gently sloping to strongly sloping soils on loess-till plains (fig. 5). Grundy soils are mainly in areas around Basehor and Pawnee soils, and Shelby soils are mainly along the west county line of Leavenworth County.

This soil association makes up about 18 percent of the counties. It is about 39 percent Grundy soils, 25 percent Pawnee soils, 20 percent Shelby soils, and 16 percent less extensive soils.

Grundy soils are gently sloping or sloping, somewhat poorly drained soils on broad convex ridgetops. They are slightly acid or medium acid throughout. They formed in loess. The surface layer is about 11

inches of black silty clay loam. The subsoil is about 32 inches thick. It is mottled silty clay loam grading to silty clay. The underlying material is mottled silty clay loam.

Pawnee soils are gently sloping and sloping, moderately well drained soils on the sides and tops of broad ridges. They are downslope from Grundy soils. They formed in glacial till. They are slightly acid or medium acid in the surface layer and subsoil. The surface layer is very dark brown clay loam about 8 inches thick. The subsoil is mottled dark grayish-brown and yellowish-brown heavy clay loam to a depth of about 49 inches. It is underlain by mottled clay loam that has spots and concretions of calcium carbonate.

Shelby soils are gently sloping to strongly sloping, moderately well drained soils that have convex to concave slopes. They are downslope from Grundy and Pawnee soils. They formed in glacial till. They are medium acid or slightly acid in the surface layer and subsoil. The surface layer is about 13 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The subsoil is dark yellowish-brown clay loam that has mottles in the lower part. The underlying material is mottled clay loam that has free calcium carbonate at a depth of 54 inches.

Of lesser extent in this association are Bremer, Elmont, Kennebec, and Sharpsburg soils and Alluvial land. Elmont soils are sloping or strongly sloping and are downslope from Shelby soils. Bremer and Kennebec soils are nearly level and are along streams. Kennebec soils are subject to frequent flooding. Sharpsburg soils are gently sloping and sloping and are on ridgetops. Alluvial land is loamy and is frequently flooded. It occupies the banks and channels of drainageways.

Most of the acreage in this association is cultivated or planted to hay or tame pasture. Soybeans, grain sorghum, and corn are the main crops. The soils have high natural fertility and high available water capacity. The main concerns in management are controlling water erosion, reducing runoff, and maintaining fertility. Good management is needed to maintain tame pasture in a vigorous condition. The main limitation for urban use is soil permeability, which limits the use of these soils for septic tank absorption fields.

Nearly Level to Steep Soils Formed in Loess and in Material Weathered from Shale and Sandstone; on Uplands

These nearly level to steep soils make up about 11 percent of the survey area. They are on loess-covered ridges and slopes underlain by shale and sandstone. About 30 percent of the acreage is cultivated. The rest is in hay and pasture and native timber. Grain sorghum, small grain, and soybeans are the principal crops in nearly level to sloping areas. Pasture grasses, hay, and timber are grown on the steeper soils. The principal management concerns are controlling soil erosion and maintaining fertility. The main limitations for urban use are slope, permeability, and shallowness over rock.

7. Martin-Grundy-Haig association

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

This soil association consists of nearly level to strongly sloping soils that formed in a mixture of loess and the residuum from shale. These soils are in a concave to depressional area below the steep limestone and shale outcrops west of Tonganoxie.

This association makes up about 4 percent of the counties. It is about 60 percent Martin soils, 21 percent Grundy soils, 12 percent Haig soils, and 7 percent less extensive soils.

Martin soils are sloping to strongly sloping and moderately well drained. The strongly sloping soils are below the limestone and shale outcrops. The sloping soils have convex to concave slopes. Martin soils formed in residuum from shale. They are slightly acid in the surface layer and in the upper part of the subsoil. They have a surface layer of very dark brown silty clay loam about 8 inches thick. The subsoil is mottled silty clay to a depth of 55 inches. The underlying material is mottled silty clay loam.

Grundy soils are gently sloping and sloping, somewhat poorly drained soils on ridgetops. They formed in loess. They are slightly acid to medium acid

throughout. The surface layer is about 11 inches of black silty clay loam. The subsoil is about 32 inches thick. It is mottled silty clay loam grading to silty clay. The underlying material is mottled silty clay loam.

Haig soils are nearly level, somewhat poorly drained soils on broad convex to slightly depressional ridgetops. They formed in loess underlain by a material that has restricted drainage. They are slightly acid. The surface layer is about 9 inches of black silty clay loam. The subsoil is about 36 inches of very firm, mottled silty clay. The underlying material is mottled, grayish-brown silty clay loam.

Of lesser extent in this association are Bremer and Elmont soils and Alluvial land. Bremer soils are nearly level and are on low terraces. Elmont soils are sloping to strongly sloping and are downslope from Martin soils. Alluvial land is loamy and is frequently flooded. It occupies the banks and channels of streams.

Most of the acreage in this association is cultivated or planted to hay or tame pasture. These soils are best suited to grain sorghum, soybeans, small grains, and only a limited amount of corn. They have high natural fertility and moderate to high available water capacity. During long periods of rain, they tend to become waterlogged. The main concerns in management are controlling erosion, reducing runoff, and maintaining fertility and tilth. The main limitations for urban use are soil texture and permeability. These soils have severe limitations for use as septic tank absorption fields.

8. Elmont-Basehor-Vinland association

Deep, well-drained, sloping and strongly sloping soils that have a silty clay loam subsoil and shallow, well drained and somewhat excessively drained, sloping to steep soils

Most of this soil association is in the southern part of Leavenworth County, on uplands adjacent to Stranger and Nine Mile Creeks. The soils are sloping to steep. They formed in residuum from sandstone or interbedded sandy and silty shale.

This association makes up about 7 percent of the counties. It is about 45 percent Elmont soils, 19 percent Basehor soils, 12 percent Vinland soils, and 24 percent less extensive soils.

Elmont soils are deep, sloping and strongly sloping, well-drained soils that have concave slopes. The surface layer is medium acid or slightly acid, very dark brown silt loam about 15 inches thick. The subsoil is mottled silty clay loam. The underlying material is yellowish-brown silty clay loam that has reddish mottles.

Basehor soils are shallow, sloping to steep, well-drained soils on erosional uplands adjacent to drainageways. They formed in residuum from soft sandstone. The surface layer is dark grayish-brown loam about 7 inches thick. The subsoil is dark yellowish-brown loam about 14 inches thick. The underlying material is yellowish-brown weathered soft sandstone. Hard sandstone is at a depth of 13 inches.

Vinland soils are shallow, sloping and strongly sloping, somewhat excessively drained soils on the convex sides and the tops of ridges. They are medium acid or

slightly acid throughout. The surface layer is very dark grayish-brown loam about 11 inches thick. The subsoil is yellowish-brown loam about 7 inches thick over weathered sandstone.

Of lesser extent in this association are Armster, Bremer, Kennebec, and Sibleyville soils and Alluvial land. Armster soils are sloping and strongly sloping and are above Basehor soils. Martin soils are sloping and are in concave positions adjacent to drainageways. Bremer and Kennebec soils are nearly level. Bremer soils are on low terraces, and Kennebec soils are on low bottoms. Sibleyville soils have concave slopes and are intermingled with Elmont and Vinland soils. Alluvial land is loamy and is frequently flooded. It occupies the banks and channels of streams.

About 50 percent of the acreage is cultivated, and the rest is in tame pasture or native grass. Elmont and Sibleyville soils are cultivated and are suited to small grain, grain sorghum, and soybeans and occasionally to corn. In places they are planted to truck gardens and berries. Vinland soils are used for tame pasture or native range. Basehor soils are used for timber, but a few acres are cleared and planted to tame grass. In cultivated areas, the main concerns in management are controlling erosion and maintaining fertility. In woodland areas, the main concern is to improve the stands of timber. In areas used for tame and native pasture, management is needed to maintain a vigorous stand of grass. The main limitations for urban use are slope, permeability, and shallowness over rock.

Sloping to Steep Soils Formed in Silty and Loamy Loess and in Material Weathered from Shale and Limestone; on Uplands

These sloping to steep soils make up about 19 percent of the survey area. They are in strongly dissected areas along major streams. Most of the acreage is in native timber and pasture. In places the less sloping soils are cultivated. Small grain and grain sorghum are the principal crops. The principal management needs are controlling erosion and maintaining fertility. Slope, permeability, and shallowness over rock are the main limitations for urban use.

9. Welda-Konawa association

Deep, well-drained, sloping to steep soils that have a clay loam and silty clay loam subsoil

This soil association consists of sloping to steep soils on the dissected south-facing bluff along the Kansas River in Leavenworth County. These soils formed in sandy and silty material.

This association makes up about 3 percent of the counties. It is about 45 percent Welda soils, 26 percent Konawa soils, and 29 percent less extensive soils.

Welda soils are sloping to moderately steep soils on the tops and convex sides of ridges. They formed in reddish-colored loess. They are medium acid or slightly acid throughout. The surface layer is about 6 inches of very dark grayish-brown silt loam. The subsurface layer is brown silt loam. The subsoil is reddish-brown silty clay loam. The underlying material is brown light silty clay loam.

Konawa soils are sloping to steep soils on the convex to concave sides and the points of ridges below Welda soils. They formed in remnants of sandy fluvial sediments on uplands. The surface layer is slightly acid, very dark grayish-brown fine sandy loam about 4 inches thick. The subsurface layer is brown fine sandy loam about 15 inches thick. The subsoil is dark-brown or brown clay loam to a depth of 47 inches. The underlying material is brown loam.

Of lesser extent in this association are Armster, Gymer, Ladoga, Sharpsburg, and Sogn soils and Alluvial land. The deep Armster, Gymer, Ladoga, and Sharpsburg soils are gently sloping to strongly sloping and are up slope from Konawa and Welda soils. The shallow Sogn soils are strongly sloping and are downslope from Konawa and Welda soils. Alluvial land is loamy and is frequently flooded. It occupies the banks and channels of drainageways.

Most of the acreage is cleared of timber and is in tame pasture. A few areas are in native timber, mainly oak and hickory. These soils are suited to small grain and grain sorghum, but are better suited to woodland and tame pasture. In cultivated areas, the main concerns in management are controlling erosion, increasing organic-matter content, and maintaining fertility. Management is needed to maintain a vigorous stand of tame grass and to improve stands of timber in most woodland areas. The main limitations for urban use are slope and permeability.

10. Gosport-Sogn association

Moderately deep, moderately well drained, strongly sloping to steep soils that have a silty clay subsoil and shallow, somewhat excessively drained, strongly sloping soils

This soil association (see figure 2, page 3) consists of strongly sloping to steep soils on uplands adjacent to the upper reaches of Stranger and Nine Mile Creeks. A large area is northwest of Leavenworth, and a smaller area is near Bonner Springs. The soils formed mainly in residuum from interbedded shale and limestone. The sloping soils on narrow ridge points formed in loess and glacial till.

This association makes up about 16 percent of the counties. It is about 35 percent Gosport soils, 16 percent Sogn soils, and 49 percent less extensive soils.

Gosport soils are moderately deep, strongly sloping to steep soils in upland areas downslope from areas of limestone outcrop. In places the surface layer is mixed with limestone rubble from the limestone outcrop above. The surface layer is very dark grayish-brown silt loam about 2 inches thick. The subsurface layer is dark grayish-brown silt loam about 4 inches thick. The subsoil is yellowish-brown silty clay about 17 inches thick and is underlain by shale.

Sogn soils are shallow, strongly sloping, and somewhat excessively drained. They are associated with limestone escarpments and intermingled with Gosport soils. The surface layer is very dark brown silty clay loam about 6 inches thick. The next layer is flaggy silty clay loam. Limestone is at a depth of 16 inches.

Of lesser extent in this association are Elmont, Grundy, Ladoga, Martin, Oska, Pawnee, Sharpsburg, and Shelby soils. Except for Elmont and Martin soils,

these deep to moderately deep soils are on narrow, convex ridgetops between the limestone rim rocks along the upland drainageways. Ladoga soils are northwest of Leavenworth and east of Stranger Creek. Grundy, Oska, Pawnee, Sharpsburg, and Shelby soils are west of Stranger Creek. The deep Elmont and Martin soils are strongly sloping and have concave slopes. They are downslope from Gosport and Sogn soils.

About 70 percent of the acreage is in native timber, such as oak and hickory. Walnut trees grow well in the deeper moist soils. The rest of the acreage is cleared and is used for tame pasture. The main concerns in management are stand improvement, good grazing management, and proper fertilization of tame pasture. The main limitations for urban use are slope and shallowness over rock. These soils can be used for wildlife habitat, greenbelts, and nature trails.

Descriptions of the Soils

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

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

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

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

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (12).²

The names of some soil series are unlike those in recently published surveys of adjacent counties. Such differences in name result from changes in the concepts of soil classification that have occurred since publication. For some series the representative profile has one or more features outside the range defined for the series. In these instances a reference is made to explain how the soil differs. Unless otherwise stated, the profiles have the characteristics within the range defined for the series.

Alluvial Land

Alluvial land (Aa) is along small streams and intermittent drainageways that have deep and meandering channels in steep, broken upland areas adjacent to the flood plain. The flood plain is 200 to 500 feet wide.

Alluvial land is about 65 percent loamy soils that formed in alluvium, which is frequently flooded; about 15 percent Kennebec silt loam, which is also frequently flooded; and 20 percent stream channels and steep, broken upland soils. Some areas are as much as 50 percent Kennebec silt loam. Included in mapping are small areas of Bremer silty clay loam on low terraces.

Flooding limits the use of Alluvial land for cultivated crops. The Kennebec soil is high in natural fertility and is suitable for cultivation, but in addition to the flood hazard, it occurs as small areas that are separated by channels and steep uplands and are commonly inaccessible.

Alluvial land is well suited to woodland, pasture, and wildlife. Oak, walnut, and sycamore trees are common. Capability unit VIw-1; woodland suitability group 3w2.

Armster Series

The Armster series consists of deep, sloping to strongly sloping, moderately well drained soils on uplands. Slopes are convex. These soils formed in glacial till.

In a representative profile the surface layer is about 5 inches of very dark grayish-brown loam. The subsurface layer is about 5 inches of brown, friable loam. The subsoil is firm clay loam to a depth of 60 inches. In sequence from the top, it is reddish brown, strong brown, yellowish brown, and pale brown.

Armster soils have available water capacity and moderately slow permeability. Natural fertility is medium, and organic-matter content is low. The surface layer is medium acid to neutral, and the subsoil is strongly acid to neutral. Lime is beneficial to most crops. Crops respond well to fertilization.

Grain sorghum, soybeans, and small grain are the main crops. The soils are suited to alfalfa, tame grasses, and woodland. The native vegetation is hardwood forest interspersed with tall grasses.

Representative profile of Armster loam, 3 to 8 percent slopes, in native vegetation 1,600 feet west and 100 feet south of the northeast corner of sec. 15, T. 11 S., R. 23 E., Wyandotte County:

² Italic numbers in parentheses refer to Literature Cited, p. 77.

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

Soil	Leavenworth	Wyandotte	Total	Extent
	County	County	area	
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Percent</i>
Alluvial land	10,690	2,130	12,820	3.2
Armster loam, 3 to 8 percent slopes	2,660	1,810	4,470	1.1
Armster loam, 8 to 12 percent slopes	2,120	2,640	4,760	1.2
Armster clay loam, 8 to 12 percent slopes, eroded	1,900	1,728	3,628	.9
Basehor complex, 5 to 30 percent slopes	3,580	2,910	6,490	1.6
Bremer silty clay loam	12,090	1,020	13,110	3.3
Elmont silt loam, 3 to 7 percent slopes	11,260	80	11,340	2.7
Elmont silt loam, 7 to 12 percent slopes	1,050	---	1,050	.2
Eudora complex, overwash	3,170	3,730	6,900	1.7
Gosport complex, 10 to 30 percent slopes	10,170	90	10,260	2.5
Gosport-Sogn complex, 7 to 35 percent slopes	25,610	8,240	33,850	8.5
Grundy silty clay loam, 1 to 3 percent slopes	15,930	660	16,590	4.1
Grundy silty clay loam, 3 to 7 percent slopes	17,060	1,660	18,720	4.6
Gymer silt loam, 3 to 7 percent slopes	630	120	750	.2
Haig silty clay loam	1,370	---	1,370	.3
Haynie silt loam	2,960	4,990	7,950	2.0
Judson silt loam	1,270	430	1,700	.4
Kennebec silt loam	13,500	2,490	15,990	4.0
Knox silt loam, 7 to 12 percent slopes	3,790	14,330	18,120	4.6
Knox silt loam, 12 to 18 percent slopes	1,800	4,890	6,690	1.6
Knox silty clay loam, 7 to 12 percent slopes, eroded	2,390	1,360	3,750	.9
Knox complex, 18 to 30 percent slopes	5,590	3,840	9,430	2.3
Konawa fine sandy loam, 3 to 8 percent slopes	1,310	130	1,440	.4
Konawa fine sandy loam, 8 to 20 percent slopes	1,340	370	1,710	.4
Ladoga silt loam, 4 to 7 percent slopes	10,760	13,380	24,140	6.0
Marshall silt loam, 1 to 4 percent slopes	720	170	890	.2
Marshall silt loam, 4 to 9 percent slopes	3,520	1,297	4,817	1.2
Marshall silt loam, 9 to 15 percent slopes	570	190	760	.2
Martin silty clay loam, 4 to 7 percent slopes	13,400	210	13,610	3.4
Martin silty clay loam, 7 to 12 percent slopes	2,450	190	2,640	.7
Martin soils, 6 to 12 percent slopes, eroded	2,950	45	2,995	.7
Onawa silty clay loam	4,000	2,380	6,380	1.6
Onawa soils, overwash	1,630	3,780	5,410	1.3
Oska silty clay loam, 3 to 8 percent slopes	1,590	120	1,710	.4
Pawnee clay loam, 1 to 4 percent slopes	2,860	---	2,860	.7
Pawnee clay loam, 4 to 8 percent slopes	13,220	1,010	14,230	3.5
Pawnee clay loam, 4 to 8 percent slopes, eroded	3,430	40	3,470	.9
Sarpy-Haynie complex	1,730	1,320	3,050	.7
Sharpsburg silty clay loam, 1 to 4 percent slopes	5,160	1,740	6,900	1.7
Sharpsburg silty clay loam, 4 to 8 percent slopes	17,050	6,060	23,110	5.8
Shelby loam, 1 to 4 percent slopes	1,730	---	1,730	.4
Shelby loam, 4 to 8 percent slopes	21,750	3,100	24,850	6.1
Shelby loam, 8 to 12 percent slopes	6,420	640	7,060	1.8
Shelby-Pawnee complex, 4 to 8 percent slopes	7,160	---	7,160	1.8
Shelby-Pawnee complex, 4 to 8 percent slopes, eroded	1,330	100	1,430	.4
Sibleyville loam, 4 to 8 percent slopes	2,240	110	2,350	.6
Vinland-Sibleyville complex, 5 to 12 percent slopes	7,300	300	7,600	1.9
Wabash silty clay	4,790	---	4,790	1.2
Welda silt loam, 4 to 9 percent slopes	2,130	830	2,960	.7
Welda silt loam, 9 to 15 percent slopes	630	460	1,090	.2
Zook silty clay loam	3,790	10	3,800	.9
Water	4,160	4,290	8,450	2.1
Quarries	370	240	610	.2
Gravel pits	---	100	100	(¹)
Total	302,080	101,760	403,840	100.0

¹ Less than 0.05 percent.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; friable, slightly hard; abundant fine and medium roots; slightly acid; clear, smooth boundary.

A—5 to 10 inches, brown (10YR 4/3) loam, pale brown (10YR 6/3) dry; weak, fine, granular structure; friable, slightly hard; abundant fine and medium roots; few worm casts; slightly acid; clear, smooth boundary.

IIB21t—10 to 20 inches, reddish-brown (5YR 4/4) heavy clay loam, strong brown (7.5YR 5/6) dry; moderate, fine, subangular blocky structure; firm, hard; plentiful fine and medium roots; some streaks of brown

(7.5YR 4/4); common glacial pebbles; strongly acid; gradual, smooth boundary.

IIB22t—20 to 29 inches, strong-brown (7.5YR 5/6) clay loam, reddish yellow (7.5YR 6/6) dry; few, fine, distinct, brown (10YR 5/3) mottles; moderate, medium and fine, subangular blocky structure; firm, hard; few fine to coarse roots; few, soft, black concretions; common glacial pebbles; strongly acid; gradual, smooth boundary.

IIB31t—29 to 40 inches, yellowish-brown (10YR 5/6 and 5/4) and strong-brown (7.5YR 5/6) clay loam, strong brown (7.5YR 5/6) crushed; weak, medium, subangular blocky structure; friable, hard; few coarse roots;

common glacial pebbles; few, soft, black concretions; strongly acid; gradual, smooth boundary.

IIB32t—40 to 60 inches, pale-brown (10YR 6/3) clay loam, light gray (10YR 7/2) dry; common, fine and medium, distinct mottles of yellowish brown (10YR 5/6); weak, coarse, blocky structure parting to weak, medium, subangular blocky; firm, hard; few coarse roots; few glacial pebbles; common, soft, black concretions; common sandstone fragments in lower 5 inches; neutral.

The solum ranges from 40 to more than 60 inches in thickness. The A1 horizon is very dark brown or very dark grayish brown. The A2 horizon is dark grayish brown or dark brown. The IIB2t horizon is reddish brown or strong brown. The IIB3t horizon is strong brown, yellowish brown, or pale brown.

Mapping unit Ae has a slightly browner surface layer than is defined as the range for the Armster series. This difference, however, does not alter the use or behavior of the soil.

Armster soils are associated with Konawa, Ladoga, Pawnee, Shelby, and Welda soils. They have hue of 7.5YR or 5YR in the B2t horizon as compared with hue of 10YR in Ladoga, Pawnee, and Shelby soils. They differ from Pawnee and Shelby soils in having an A2 horizon. They have more glacial sand and gravel in the B2t horizon than Konawa, Ladoga, and Welda soils and more clay in the B2t horizon than Shelby soils.

Armster loam, 3 to 8 percent slopes (Ac).—This soil has convex slopes. It has the profile described as representative of the series. Included in mapping are small areas of Ladoga and Welda soils and small areas of eroded soil.

This soil is best suited to grain sorghum, soybeans, and small grain. It is also suited to alfalfa, tame pasture, and woodland. To a limited extent it is suited to corn.

Erosion is a serious hazard, but can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Fertility and organic-matter content can be increased by applying farm manure and growing legumes and green manure crops. Capability unit IIIe-3; woodland suitability group 4o1.

Armster loam, 8 to 12 percent slopes (Ad).—This soil has irregular, convex and concave slopes. Its profile is similar to the one described as representative of the series, but the subsoil contains less clay. Included in mapping are areas of soils that are similar to the Armster soil but have sandstone at a depth of about 40 inches.

This soil is best suited to hay, tame pasture, and woodland. It is also suited to grain sorghum and small grain and, to a limited extent, to corn or soybeans.

Runoff is rapid, and erosion is a serious hazard. Maintaining tilth and the level of fertility and controlling erosion are a necessary part of good management. Terraces, contour farming, minimum tillage, or stubble mulching, or a combination of these practices is needed for erosion control. Manure is beneficial in maintaining the organic-matter content. Proper grazing and fertilization are needed in maintaining vigorous stands of tame grass. Stands can be improved in the small areas of native timber. Capability unit IVe-3; woodland suitability group 4o1.

Armster clay loam, 8 to 12 percent slopes, eroded (Ae).—This soil has short, irregular, convex and concave slopes. Its profile is similar to the one described as representative of the series, but the surface layer

is dark-brown or brown clay loam and contains more clay.

Included with this soil in mapping are small areas of eroded Ladoga and Welda soils. Also included are areas of soils that are similar to this Armster soil but have sandstone at a depth of about 40 inches.

This soil is best suited to hay, tame pasture, or woodland. Tame grasses can be kept vigorous under controlled and deferred grazing and fertilization. Capability unit VIe-1; woodland suitability group 4o1.

Basehor Series

The Basehor series consists of shallow, sloping to steep, well-drained soils on uplands. These soils formed in residuum from sandstone (fig. 6).

In a representative profile the surface layer is about 7 inches of dark grayish-brown loam. The subsoil is dark yellowish-brown, friable loam about 3 inches thick. The underlying material is about 3 inches of yellowish-brown loamy fine sand. Weathered sandstone is at a depth of 13 inches.

Basehor soils have very low available water capacity, moderately rapid permeability, and low natural fertility. They are medium acid or slightly acid in the surface layer. Lime is beneficial to tame grass.

The native vegetation is oak and hickory. Some areas are cleared of timber and planted to tame grass. The soils are suited to tame grass and woodland.

Representative profile of Basehor loam in a pasture, 1,275 feet south and 320 feet east of the northwest corner of sec. 8, T. 11 S., R. 23 E., about 3.75 miles north of Bonner Springs, Wyandotte County:

A1—0 to 7 inches, dark grayish-brown (10YR 4/2) loam, light brownish gray (10YR 6/2) dry; weak, medium and fine, granular structure; friable, slightly hard; many fine roots; few worm casts; slightly acid; gradual boundary.

B2—7 to 10 inches, dark yellowish-brown (10YR 4/4) loam that has slightly more clay than horizon above, light yellowish brown (10YR 6/4) dry; weak, medium and fine, granular structure; friable, slightly hard; many fine roots; few, small, soft sandstone fragments; medium acid; abrupt boundary.

C—10 to 13 inches, yellowish-brown (10YR 5/4), soft, fine-grained sandstone, brownish yellow (10YR 6/6) dry; thinly bedded with thin films of reddish brown (5YR 5/4) in seams and partings; medium acid; clear boundary.

R—13 inches, brownish-yellow (10YR 6/6) to yellowish-brown (10YR 5/6) hard, fine-grained sandstone.

The solum ranges from 10 to 20 inches in thickness. Depth to sandstone or sandy shale is 20 inches or less. The solum is slightly acid to strongly acid. The A1 horizon is very dark grayish-brown or dark grayish-brown loam or fine sandy loam. The B2 horizon is loam or fine sandy loam. In places there is no C horizon.

Basehor soils are associated with Elmont and Vinland soils. They have less clay in the B2 horizon than Elmont soils, which are more than 20 inches deep. They lack the thicker, dark-colored A1 horizon that is typical of Vinland soils.

Basehor complex, 5 to 30 percent slopes (Ba).—This mapping unit is about 55 percent Basehor loam; 30 percent soils that are 20 to 40 inches deep and have a loamy surface layer and subsoil; and 15 percent Vinland soils and loamy soils that are less than 10 inches deep. These soils are on erosional uplands, generally adjacent to drainageways. They are shal-



Figure 6.—Moderately steep Basehor soils on breaks to the drainageway and sloping Sharpsburg and Shelby soils on loess and till ridges.

low and moderately deep loamy soils that formed in material weathered from sandstone. About half of the 30 percent loamy soils are similar to the Basehor soils in color and texture, but they are 20 to 40 inches deep. The other half are soils that have a loam surface layer and a clay loam subsoil and are 20 to 40 inches deep. All the soils in this mapping unit have a surface layer of loam or fine sandy loam.

Most of the acreage is woodland. Some areas are cleared of timber and planted to tame grass. Tame grass responds well to fertilization and can be kept vigorous under good grazing management.

Water erosion is a serious hazard unless the soil is protected by a permanent cover. Native timber can be improved under good woodland management. Stands can be improved. Capability unit VIe-2; woodland suitability group 5d2.

Bremer Series

The Bremer series consists of deep, nearly level, somewhat poorly drained soils. These soils are on high bottom lands and terraces along tributaries of the Kansas and Missouri Rivers. They formed in moderately fine textured alluvium.

In a representative profile the surface layer is about 9 inches of black silty clay loam. The subsoil is about 41 inches thick. In sequence from the top, it is 4 inches of black, firm silty clay loam; 21 inches of very

dark gray, very firm silty clay; and 16 inches of grayish-brown, firm silty clay loam. Below the top 4 inches the subsoil has yellowish-brown or strong-brown mottles. The underlying material is mixed grayish-brown and yellowish-brown silty clay loam.

Bremer soils have high natural fertility and are high in organic-matter content. Available water capacity is high, and permeability is slow. The surface layer is neutral or slightly acid, and the subsoil is slightly acid or medium acid. Lime is beneficial to most crops. The soils are rarely flooded.

The native vegetation is tall grasses. Most of the acreage is cultivated. Corn, soybeans, and grain sorghum are the main crops.

Representative profile of Bremer silty clay loam, 0 to 2 percent slopes, in a cultivated field, 2,500 feet north and 1,100 feet east of southwest corner of sec. 24, T. 11 S., R. 20 E., Leavenworth County:

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak, fine and medium, angular and subangular blocky structure; weak, fine, granular structure in top 3 inches; firm, hard; plentiful fine and medium roots; common worm casts; neutral; abrupt, smooth boundary.

B1—9 to 13 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate, fine and very fine, subangular blocky structure; firm, hard; few fine roots; few worm casts; slightly acid; clear, smooth boundary.

B21t—13 to 22 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings

on peds; common, fine, faint, yellowish-brown (10YR 5/6) mottles and few, fine, distinct, strong-brown (7.5YR 5/6) mottles; moderate, fine and medium, subangular blocky structure; very firm, very hard; medium acid; clear, smooth boundary.

B2t—22 to 34 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; common, fine, faint, yellowish-brown (10YR 5/4 and 10YR 5/6) mottles and few, fine, distinct, strong-brown (7.5YR 5/6) mottles; moderate, medium, subangular blocky structure; very firm, very hard; few fine roots; few, hard, round, black concretions; few streaks of black (10YR 2/1); medium acid; diffuse, smooth boundary.

B3—34 to 50 inches, grayish-brown (10YR 5/2) heavy silty clay loam, light brownish gray (10YR 6/2) dry; common, fine and medium, yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky structure; firm, hard; few, soft, black concretions; slightly acid; gradual, smooth boundary.

C—50 to 70 inches, mixed grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) silty clay loam, few, fine, strong-brown (7.5YR 5/6) mottles; weak, coarse, prismatic structure; firm, hard; common, soft, black concretions; neutral.

The solum ranges from 50 to 65 inches in thickness. The A horizon is black to very dark grayish-brown silty clay loam, but it is silt loam in places. The B2 horizon is mottled very dark gray or very dark grayish brown in the upper part and mottled dark gray or dark grayish brown in the lower part.

Bremer soils are associated with Judson, Kennebec, Wabash, and Zook soils. They contain more clay throughout than Judson and Kennebec soils. They are less clayey than Wabash soils below a depth of 40 inches and, unlike those soils, have a B2t horizon. They are less uniform in texture than Zook soils and, unlike those soils, have a B2t horizon.

Bremer silty clay loam (0 to 2 percent slopes) (Br).—This soil has the profile described as representative of the series. Included in mapping are small areas adjacent to the recent channel or flood plain where the surface layer is lighter colored. Also included are small areas of Judson soils.

If adequately fertilized and limed, this soil is suited to most crops grown in the county, especially soybeans, corn, and grain sorghum. It is also suited to tame pasture. During periods of above average moisture, the soil tends to become waterlogged and in places ponded. Capability unit IIw-1; woodland suitability group 4w2.

Elmont Series

The Elmont series consists of deep, sloping and strongly sloping, well-drained soils on uplands. These soils formed in residuum from interbedded sandy and silty shales.

In a representative profile the surface layer is very dark brown silt loam about 15 inches thick (fig. 7). The subsoil is friable and firm silty clay loam about 35 inches thick. It is very dark grayish brown in the upper part, mottled dark brown in the middle part, and yellowish brown in the lower part. The underlying material is mottled yellowish-brown silty clay loam. Weathered silty shale of light olive brown is at a depth of 65 inches.

Elmont soils are friable and easy to work. They have high available water capacity and fertility and moderately slow permeability. The surface layer is medium acid or slightly acid. Lime is beneficial to most crops, especially legumes. Crops also respond well to fertilization.

These soils are suited to grain sorghum, corn, soybeans, and small grain. They are also suited to alfalfa and tame pasture. A few small areas are in tall grass meadow. The native vegetation is tall grass.

Representative profile of Elmont silt loam, 3 to 7 percent slopes, in tame pasture, 1,900 feet north and 150 feet west of the southeast corner of sec. 31, T. 11 S., R. 22 E., Leavenworth County:

A1—0 to 15 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard; plentiful fine and medium roots; common worm casts and channels; medium acid; gradual, smooth boundary.

B2t—15 to 22 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, very fine, subangular blocky structure;



Figure 7.—Profile of Elmont silt loam.

friable, hard; plentiful fine roots; few sandstone fragments; common worm casts and channels; medium acid; gradual, smooth boundary.

B22t—22 to 33 inches, dark-brown (10YR 4/3) silty clay loam, brown (10YR 5/3) dry; common, fine, faint, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; friable, hard; plentiful fine and medium roots; few worm casts and channels; few weathered sandstone fragments; common very dark grayish-brown (10YR 3/2) surfaces on peds; few, soft black concretions; neutral; gradual, smooth boundary.

B23t—33 to 42 inches, dark-brown (10YR 4/3) silty clay loam, yellowish brown (10YR 5/4) dry; few, fine, faint and distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; moderate, medium and fine, subangular blocky structure; firm, hard; few fine roots; few, soft, black concretions; few weathered sandstone fragments; neutral; diffuse, smooth boundary.

B3—42 to 50 inches, yellowish-brown (10YR 5/4) silty clay loam, light yellowish brown (10YR 6/4) dry; many, fine, distinct, yellowish-red (5YR 4/6) mottles; moderate, medium, subangular blocky structure; firm, hard; few fine roots; common black concretions; common weathered sandstone fragments; neutral; diffuse, smooth boundary.

C1—50 to 65 inches, yellowish-brown (10YR 5/6 and 5/4) silty clay loam; many, fine, distinct, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/6) mottles; weak, coarse, blocky structure; few fine roots; few black concretions and soft spots; common weathered sandstone fragments in lower part; neutral; diffuse, smooth boundary.

The solum ranges from 40 to 50 inches in thickness. Depth to weathered shale is 40 to 80 inches. The A1 horizon is generally silt loam, but it is silty clay loam in places. The B2t horizon is dark grayish brown or dark brown and is medium acid to neutral. The C horizon is generally silty clay loam, but in places it is silty clay.

Elmont soils are associated with Basehor, Martin, Sharpsburg, Sibleyville, and Vinland soils. They contain more silt throughout and have a thicker solum than Basehor soils. They have less clay in the B2t horizon than Martin soils. They have less sand in the B2t horizon and have a thicker solum than Sibleyville soils. They have a thicker solum than Vinland soils. They have less clay in the B2t horizon than Sharpsburg soils and are more distinctly mottled.

Elmont silt loam, 3 to 7 percent slopes (Ec).—This soil is on the convex to concave sides and the convex tops of ridges. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Martin, Sibleyville, and Vinland soils. Also included are small areas of a soil similar to this Elmont soil, but shale is within a depth of 40 inches. Spots of eroded soils and slickspots are also included.

This soil is suited to grain sorghum, corn, soybeans, and small grain. In places it is used for tame pasture.

Erosion is a hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Maintaining fertility is essential and can be accomplished by growing legumes and green manure crops. Tame pasture grasses can be kept vigorous under good grazing management and proper fertilization. Capability unit IIIe-1; not assigned to a woodland suitability group.

Elmont silt loam, 7 to 12 percent slopes (Ed).—This soil has convex and concave slopes. It has a profile similar to that described as representative of the series, but the surface layer and solum are thinner.

Included with this soil in mapping are small areas of Martin, Sibleyville, and Vinland soils. Also included are small areas of a soil similar to this Elmont soil, but shale is within a depth of 40 inches. Spots of eroded soils are also included.

This soil is suited to small grain and grain sorghum in the less steep areas and to hay or tame pasture in the steeper areas.

Erosion is a serious hazard, but it can be controlled by terraces, minimum tillage, or stubble mulching, or by a combination of those practices. Good stands of tame pasture grasses can be sustained under proper grazing management and proper fertilization. Capability unit IVe-1; not assigned to a woodland suitability group.

Eudora Series

The Eudora series consists of nearly level, well-drained soils on high bottom land along the Kansas River. These soils are neutral to moderately alkaline. They formed in silty alluvium.

In a representative profile the surface layer is about 24 inches thick. The upper 9 inches is dark grayish-brown very fine sandy loam. The next 3 inches is grayish-brown loamy very fine sand. The lower 12 inches is very dark grayish-brown coarse silt loam. Below the surface layer is about 10 inches of dark-brown coarse silt loam, 31 inches of brown very fine sandy loam, and 5 inches of brown loamy fine sand.

Eudora soils have high available water capacity and moderate permeability. They are high in natural fertility and are easy to work. All crops respond well to fertilization. No lime is needed. Organic-matter content is low in the surface layer.

These soils are well suited to corn, soybeans, grain sorghum, and small grain. They are also excellent for truck farming.

Representative profile of Eudora very fine sandy loam in a cultivated field, 300 feet north and 100 feet east of center of sec. 28, T. 11 S., R. 24 E., about one-fourth mile north of Morris, Wyandotte County:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) very fine sandy loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; very friable, slightly hard; few fine roots; neutral; abrupt, smooth boundary.

A12—9 to 12 inches, grayish-brown (10YR 5/2) loamy very fine sand, light gray (10YR 7/2) dry; single grained; very friable, soft; few fine roots; neutral; abrupt, smooth boundary.

A13—12 to 24 inches, very dark grayish-brown (10YR 3/2) coarse silt loam; few, fine, faint mottles of yellowish brown (10YR 5/4) and dark grayish brown (10YR 4/2); friable, slightly hard; few fine roots; neutral; clear, smooth boundary.

C1—24 to 34 inches, dark-brown (10YR 4/3) coarse silt loam, pale brown (10YR 6/3) dry; friable, slightly hard; few fine roots; moderately alkaline; gradual, smooth boundary.

C2—34 to 65 inches, brown (10YR 5/3) very fine sandy loam, very pale brown (10YR 7/3) dry; massive; very friable, soft; moderately alkaline; gradual, smooth boundary.

C3—65 to 70 inches, brown (10YR 5/3) loamy fine sand, very pale brown (10YR 7/3) dry; single grained; loose; moderately alkaline.

The Ap horizon is very dark grayish brown or dark grayish brown and ranges from fine sandy loam to silt loam. In places

there is no A12 horizon. In most places the A13 horizon, the original surface layer, is covered with calcareous alluvium deposited during a major flood. It is very dark brown or very dark grayish-brown silt loam. The C horizon is generally very fine sandy loam or coarse silt loam to a depth of 45 inches or more. In places it is fine sand or loamy fine sand below a depth of 45 inches.

Eudora soils are associated with Haynie, Kennebec, Onawa, and Sarpy soils. Unless covered with more than 20 inches of overwash, they have a thicker, dark-colored A1 horizon than Haynie and Sarpy soils. Throughout the profile they have less sand than Sarpy soils, more coarse silt than Kennebec soils, and less clay than Onawa soils.

Eudora complex, overwash (0 to 1 percent slopes) (Eu).—This mapping unit is about 70 percent Eudora soil and 20 percent Haynie soil. The Eudora soil is covered with 10 to 20 inches of lighter colored fine sand or very fine sand. The surface layer is silt loam, very fine sandy loam, fine sandy loam, and loamy very fine sand. Most areas have been plowed to a depth of 18 to 24 inches, and as a result, the surface layer contains much sand.

Included with these soils in mapping are areas of Onawa soils in depressions and areas of soils that are sandy throughout.

These soils are suited to all crops commonly grown in the counties. They are especially suited to truck crops, and they can be irrigated from wells or from the river. They are rarely flooded.

Soil blowing is a hazard because the surface layer is sandy. It can be controlled by such practices as stubble mulching and minimum tillage. Manure increases the organic-matter content in the surface layer. Capability unit I-1; woodland suitability group 2o1.

Gosport Series

The Gosport series consists of moderately deep, strongly sloping to steep, moderately well drained soils on uplands. These soils formed in residuum from shale.

In a representative profile the surface layer is very dark grayish-brown silt loam about 2 inches thick. The subsurface layer is about 4 inches of dark grayish-brown silt loam. The subsoil is yellowish-brown, very firm silty clay about 17 inches thick. The underlying material is dark grayish-brown and yellowish-brown weathered shale of silty clay texture. Yellowish-brown acid shale is at a depth of 33 inches.

Gosport soils have low to moderate available water capacity and very slow permeability. Natural fertility is low. The surface layer is slightly acid or medium acid.

These soils are best suited to woodland, and the native vegetation is hardwood forest. In areas cleared for tame pasture, lime and fertilizer are beneficial.

Representative profile of Gosport loam under native timber, 250 feet east and 300 feet south of northwest corner of sec. 30, T. 8 S., R. 22 E., Leavenworth County:

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

A2—2 to 6 inches, dark grayish-brown (10YR 4/2) silt loam, pale brown (10YR 6/3) dry; weak, fine and medium, granular structure; friable, hard; few fine roots; few

worm casts; common shale fragments; strongly acid; abrupt, smooth boundary.

B2—6 to 23 inches, yellowish-brown (10YR 5/4) silty clay, very pale brown (10YR 7/4) dry; moderate, medium, sub-angular blocky structure; very firm, very hard; few fine and medium roots; common shale fragments; very strongly acid; clear, smooth boundary.

C1—23 to 33 inches, dark grayish-brown (10YR 4/2) and yellowish-brown (10YR 5/4 and 5/6) silty clay weathered shale; massive with bedding planes evident; very firm, very hard; few fine and medium roots; strongly acid; gradual, smooth boundary.

C2—33 to 40 inches, yellowish-brown (10YR 5/4) acid shale.

The solum ranges from 20 to 35 inches in thickness. Depth to shale ranges from 20 to 40 inches. The A1 horizon is very dark grayish-brown or dark grayish-brown silt loam or light silty clay loam. The A2 horizon is dark grayish-brown or dark-brown silt loam or light silty clay loam. In places there is no A2 horizon. The B2 horizon is strongly acid or very strongly acid.

Gosport soils are associated with Martin and Sogn soils. They are shallower over shale than Martin soils and have a thinner and lighter colored A horizon. They have a thicker solum than Sogn soils and, unlike those soils, formed in shale instead of limestone.

Gosport complex, 10 to 30 percent slopes (Gc).—This mapping unit is about 50 percent Gosport soil; 15 percent a soil similar to the Gosport soil, but less than 20 inches deep over shale; and 35 percent less extensive soils. These soils are along major creeks in the uplands. They are deep, moderately deep, and shallow over shale. The Gosport soil has the profile described as representative of the series. Included in the western part of Leavenworth County are numerous small areas of Martin and Elmont soils.

This mapping unit is best suited to native timber, such as oak and hickory. In places walnut trees grow in the deeper moist soils. A small acreage of moderately steep soils is cleared of timber and used for tame pasture (fig. 8).

Water erosion is a serious hazard after clearing, and permanent cover is needed immediately. Good woodland management, such as selective cutting and stand reduction, is essential. Tame pasture can be kept vigorous under good grazing management and additions of lime and fertilizer. Capability unit VIIe-1; woodland suitability group 5d2.

Gosport-Sogn complex, 7 to 35 percent slopes (Gs).—This mapping unit is about 45 percent Gosport soil, 35 percent Sogn soil, and 20 percent Martin, Elmont, and Oska soils. These soils are along major creeks and rivers in the uplands. They are moderately deep or shallow over interbedded limestone and shale. The Gosport soil has a profile similar to the one described as representative of the series, but in many places it is covered with limestone rubble above limestone outcrop. The Sogn soil has the profile described as representative of the series.

This mapping unit is best suited to native timber. A few of the strongly sloping and moderately steep soils are cleared of timber and used for tame pasture. Water erosion is a serious hazard after clearing, and permanent cover is needed immediately. Good woodland management, such as selective cutting and stand reduction, is needed. Tame pasture can be kept vigorous under good grazing management and applications of lime and fertilizer. Capability unit VIIe-1; woodland suitability group 5d2.



Figure 8.—A cleared area of the moderately steep Gosport complex between sloping Martin soils under cultivation and the steep Gosport-Sogn complex.

Grundy Series

The Grundy series consists of deep, gently sloping and sloping, somewhat poorly drained soils that have a clayey subsoil. These soils are on uplands. They formed in loess.

In a representative profile the surface layer is about 11 inches of black light silty clay loam. The subsoil is about 32 inches thick. In sequence from the top, it is 4 inches of very dark gray, firm silty clay loam that has brownish mottles; 7 inches of dark grayish-brown, very firm silty clay that has yellowish-brown and strong-brown mottles; 8 inches of grayish-brown and brown, very firm silty clay that has brownish mottles; and 13 inches of grayish-brown, firm silty clay loam that has brownish mottles. The underlying material is grayish-brown and yellowish-brown silty clay loam.

Grundy soils have high available water capacity and slow permeability. The surface layer is medium acid or slightly acid. Lime is beneficial to most crops. Crops also respond well to fertilization.

Corn, soybeans, and grain sorghum are the main crops. The soils are suited to tame grasses. The native vegetation is tall grasses.

Representative profile of Grundy silty clay loam, 1 to 3 percent slopes, in a cultivated field, 300 feet north

and 2,000 feet west of the southeast corner of sec. 23, T. 10 S., R. 22 E., Leavenworth County:

- Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) dry; weak, medium, angular parting to weak, fine, granular structure (compacted); surface 3 inches moderate, fine, granular structure; friable, hard; plentiful fine roots; few worm casts; slightly acid; abrupt, smooth boundary.
- A12—8 to 11 inches, black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) dry; moderate, very fine and fine, subangular blocky structure; friable, hard; common fine roots; medium acid; clear, smooth boundary.
- B1—11 to 15 inches, very dark gray (10YR 3/1) medium silty clay loam, dark gray (10YR 4/1) dry; few, fine, faint, brown (10YR 5/3) mottles; moderate, fine and very fine, subangular blocky structure; firm, hard; few fine roots; medium acid; clear, smooth boundary.
- B21t—15 to 22 inches, dark grayish-brown (10YR 4/2) light silty clay, grayish brown (10YR 5/2) dry; common, fine, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; moderate, coarse, blocky structure; very firm, very hard; few fine roots; common, small, round, black concretions; very dark gray (10YR 3/1) on many ped surfaces; medium acid; clear, smooth boundary.
- B22t—22 to 30 inches, mixed grayish-brown (10YR 5/2) and brown (10YR 5/3) light silty clay; many, fine, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; moderate, coarse, blocky parting to moderate to weak, medium and fine, subangular blocky structure; very firm, very hard; few fine

roots; common, small, round, black concretions; common, diagonal, very dark gray (10YR 3/1) streaks; slightly acid; gradual, smooth boundary.

B3t—30 to 43 inches, grayish-brown (2.5Y 5/2) heavy silty clay loam, light brownish gray (2.5Y 6/2) dry; many, fine and medium, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, blocky parting to moderate to weak, medium, subangular blocky structure; firm, hard; few fine and medium roots; few, small, round, black concretions and soft black spots; neutral; diffuse, smooth boundary.

C—43 to 65 inches, mixed grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) medium silty clay loam; common, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, coarse, prismatic structure; firm, hard; neutral; diffuse, smooth boundary.

The solum ranges from 40 to 60 inches in thickness. The Ap horizon is black or very dark grayish-brown light silty clay loam. The B2t horizon has hue of 10YR or 2.5Y, value of 3, 4, or 5, and chroma of 1, 2, or 3 when moist. It is dominantly light silty clay that has yellowish-brown and strong-brown mottles throughout and yellowish-red mottles in the upper part. In most places small, round, black concretions are common in the B2t horizon. The C horizon is dominantly grayish-brown silty clay loam, but in places it is gray, dark grayish-brown, or brown. Yellowish-brown and strong-brown mottles are common in this horizon.

Grundy soils are associated with Haig, Martin, Pawnee, Sharpsburg, and Shelby soils. They lack the abrupt transition between the A horizon and the B2t horizon that is typical of Haig soils. In contrast with Pawnee and Shelby soils, they formed in loess instead of glacial till, and consequently have no glacial sand and gravel in the profile. They have more clay in the B2t horizon than Sharpsburg and Shelby soils. They have mottles higher in the B2t horizon than Sharpsburg soils. They do not have the dense B2t horizon that is typical of Martin soils and, unlike those soils, formed in loess instead of residuum from shale.

Grundy silty clay loam, 1 to 3 percent slopes (Gt).—This soil is on ridgetops. It has the profile described as representative of the series. Included in mapping are small areas of Sharpsburg soil, mostly at the ends of narrow ridgetops.

This soil is well suited to all crops commonly grown in the counties. It has high natural fertility and can be used intensively if fertility is maintained. In places it becomes waterlogged during periods of above average rainfall. Erosion is not a serious hazard, and it can be controlled by contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Capability unit IIe-2; not assigned to a woodland suitability group.

Grundy silty clay loam, 3 to 7 percent slopes (Gu).—This soil has concave to convex slopes. It has a profile similar to that described as representative of the series, but the A horizon is thinner and the subsoil contains less clay.

Included with this soil in mapping are areas of Pawnee soils along and at the heads of drainageways and areas of Shelby soils that are below this Grundy soil. Wet spots are common at the boundary between Grundy and Pawnee soils. Also included are areas of eroded soils, but these areas are not large enough to manage separately.

This soil has high natural fertility, and is well suited to most crops in the county. In cultivated areas, it is susceptible to moderate water erosion. Terraces, contour farming, minimum tillage or stubble mulching, or a combination of those practices is needed. Capability unit IIIe-2; not assigned to a woodland suitability group.

Gymer Series

The Gymer series consists of deep, sloping, well-drained soils on uplands. These soils formed in loess.

In a representative profile the surface layer is very dark grayish-brown silt loam and silty clay loam about 10 inches thick. The subsoil is about 29 inches thick. It is very dark grayish-brown and dark-brown, friable silty clay loam in the upper 4 inches; reddish-brown, firm heavy silty clay loam in the next 7 inches; and yellowish-red and strong-brown, firm silty clay loam in the lower 18 inches. The underlying material is dark-brown silty clay loam.

Gymer soils have high available water capacity, moderately slow permeability, and high fertility. They are medium acid or slightly acid throughout. Lime is beneficial to most crops, especially legumes.

The native vegetation is tall grass. Most of the acreage is cultivated, and the main crops are corn, soybeans, grain sorghum, and wheat. The soils are suited to orchards and tame pasture.

Representative profile of Gymer silt loam, 3 to 7 percent slopes, about 1 mile south of the junction of Interstate 70 and State Highway 32, 1,400 feet south and 200 feet east of the northwest corner of sec. 23, T. 12 S., R. 20 E., Leavenworth County:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; friable, slightly hard; abundant fine roots; few worm casts; medium acid; abrupt, smooth boundary.

A12—7 to 10 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, very fine, subangular blocky structure; friable, slightly hard; abundant fine roots; few worm casts; medium acid; clear, smooth boundary.

B1—10 to 14 inches, very dark grayish-brown (10YR 3/2) and dark-brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/2) crushed, dark grayish brown (10YR 4/2) dry; moderate, fine, subangular blocky structure; friable, hard; plentiful fine roots; medium acid; clear, smooth boundary.

B21t—14 to 21 inches, reddish-brown (5YR 4/4) heavy silty clay loam, reddish brown (5YR 5/4) dry; dark reddish-brown (5YR 3/3) coatings on ped surfaces; moderate, medium and fine, subangular blocky structure; firm, hard; plentiful fine roots; medium acid; clear, smooth boundary.

B22t—21 to 28 inches, yellowish-red (5YR 4/6) silty clay loam, reddish yellow (5YR 6/6) dry; reddish-brown (5YR 4/3) coatings on ped surfaces; moderate to weak, medium, subangular blocky structure; firm, hard; few fine and medium roots; medium acid; gradual, smooth boundary.

B3—28 to 39 inches, strong-brown (7.5YR 5/6) silty clay loam, reddish yellow (5YR 6/6) dry; weak, coarse, blocky structure; firm, hard; few fine roots; few manganese spots; porous; medium acid; gradual, smooth boundary.

C—39 to 60 inches, dark-brown (7.5YR 4/4) silty clay loam, brown (7.5YR 5/4) dry; weak, coarse, prismatic structure; friable, hard; few fine roots; porous; medium acid; gradual, smooth boundary.

The solum ranges from 36 to 50 inches in thickness. The A horizon is very dark brown or very dark grayish-brown silt loam or light silty clay loam. It is slightly acid or medium acid. The B1 horizon is very dark grayish brown or dark brown. The B2t horizon is reddish-brown to yellowish-red silty clay loam. In places the B2t horizon is brown or yellowish brown and has reddish-brown or yellowish-red mottles. The C horizon is dark brown or strong brown.

Gymer soils are associated with Konawa, Sharpsburg, and Welda soils. They have a browner B2t horizon than Sharps-

burg soils. They are more silty throughout than Konawa soils. They have a thicker, dark-colored A1 horizon than Welda soils.

Gymer silt loam, 3 to 7 percent slopes (Gy).—This soil is on the convex to concave sides and on the tops of ridges. Included in mapping are small areas of Konawa, Sharpsburg, and Welda soils. Also included are spots of eroded soils.

Water erosion is a hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. This soil responds well to fertilization and is suited to most crops grown in the county. Farm manure is beneficial in maintaining organic-matter content. Capability unit IIIe-1; not assigned to a woodland suitability group.

Haig Series

The Haig series consists of deep, nearly level, somewhat poorly drained soils that have a clayey subsoil. These soils are on uplands. They formed in moderately fine textured loess.

In a representative profile the surface layer is about 9 inches of black silty clay loam. The subsoil is about 36 inches of very firm and firm silty clay that has strong-brown and yellowish-brown mottles. It is very dark gray in the upper 11 inches, dark gray and very dark gray in the middle 7 inches, and grayish brown in the lower 18 inches. The underlying material is grayish-brown silty clay loam.

Haig soils have moderate available water capacity, slow permeability, and high natural fertility. They are neutral to slightly acid. Crops respond well to fertilization.

Most of the acreage is cultivated. The soils are well suited to hay and tame pasture. If cultivated, they are best suited to grain sorghum, soybeans, and small grain. Corn can be grown occasionally. The native vegetation is tall prairie grasses.

Representative profile of Haig silty clay loam (0 to 1 percent slopes), in a cultivated field 2,500 feet west and 1,000 feet north of southeast corner of sec. 18, T. 12 S., R. 21 E., about 5.5 miles west of Linwood, Leavenworth County:

Ap—0 to 9 inches, black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) dry; weak, fine, granular structure; firm; hard; plentiful fine and medium roots; few worm casts; neutral; abrupt, smooth boundary.

B21t—9 to 20 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; few, fine, faint, yellowish-brown (10YR 5/6 and 5/4) strong-brown (7.5YR 5/6) mottles; moderate, fine, angular and subangular blocky structure; very firm, very hard; distinct clay films; few fine roots, 1/4 inch krotovinas; slightly acid; clear, smooth boundary.

B22t—20 to 27 inches, mixed dark gray (10YR 4/1) and very dark gray (10YR 3/1) silty clay; common, fine, distinct, yellowish-brown (10YR 5/6 and 5/4) and strong-brown (7.5YR 5/6) mottles; moderate, medium, angular and subangular blocky structure; very firm, very hard; few medium and fine roots; common, round, black concretions; distinct continuous clay films; slightly acid; clear, smooth boundary.

B23t—27 to 35 inches, grayish-brown (2.5Y 5/2) silty clay, light brownish gray (2.5Y 6/2) dry; many, fine and medium, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, medium and fine, angular and subangular blocky structure; very

firm, very hard; few fine roots; common dark streaks of very dark gray (10YR 3/1); continuous clay films; few, round, black concretions; slightly acid; clear, smooth boundary.

B3—35 to 45 inches, grayish-brown (10YR 5/2) light silty clay, light brownish gray (10YR 6/2) dry; common, fine and medium, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; firm, hard; few fine roots; common, round, black concretions; many open pores; neutral; diffuse, smooth boundary.

C—45 to 60 inches, grayish-brown (10YR 5/2) medium silty clay loam, light brownish gray (10YR 6/2) dry; common, fine and medium, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, prismatic structure; firm, hard; many open pores; neutral; diffuse, smooth boundary.

The solum ranges from 35 to 60 inches in thickness. The A horizon is 8 to 13 inches thick and ranges from black to very dark grayish brown. In places calcium carbonate concretions are common below a depth of 45 inches.

Haig soils are near Grundy and Martin soils. They do not have a B1 horizon, which is typical of Grundy soils. They have a more dense B2t horizon than Martin soils, which formed in residuum from shale.

Haig silty clay loam (0 to 1 percent slopes) (Hg).—This soil is on broad ridgetops. Included in mapping are small areas of Grundy and Martin soils.

Because the subsoil is dense and runoff is slow, this soil commonly is wet enough during periods of high rainfall to adversely affect the roots of young plants, especially corn. Erosion is a slight hazard in cultivated areas, but it can be controlled by contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Capability unit IIs-1; not assigned to a woodland suitability group.

Haynie Series

The Haynie series consists of deep, nearly level, well-drained soils that are calcareous. These soils are on bottom land along the Kansas and Missouri Rivers. They formed in loamy alluvium.

In a representative profile the surface layer is about 8 inches of very dark grayish-brown silt loam. The underlying material is dark grayish-brown coarse silt loam in the upper 18 inches and grayish-brown very fine sandy loam in the lower 34 inches. It is mottled with strong brown.

Haynie soils have high available water capacity. Permeability is moderate, and natural fertility and organic-matter content are medium.

The native vegetation is deciduous trees common to the area. Most areas are cleared of timber. Soybeans, small grain, and corn are the main crops. The soils are well suited to vegetables.

Representative profile of Haynie silt loam, in a cultivated field, 2,400 feet east and 1,000 feet south of northwest corner of sec. 24, T. 10 S., R. 24 E., Leavenworth County:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; friable, slightly hard; common worm casts; slight effervescence; moderately alkaline; abrupt, smooth boundary.

C1—8 to 26 inches, dark grayish-brown (10YR 4/2) coarse silt loam, light brownish gray (10YR 4/2) dry; weak, fine, faint mottles of strong brown (7.5YR 5/6) along root channels; weak, fine, granular structure; friable, slightly hard; few worm casts; strong effervescence; moderately alkaline; diffuse, smooth boundary.

C2—26 to 60 inches, grayish-brown (2.5Y 5/2) heavy very fine sandy loam, light gray (2.5Y 7/2) dry; common, fine, faint, mottles of strong brown (7.5YR 5/6) along root channels; weak, very fine, platy structure; friable, slightly hard; strong effervescence; moderately alkaline.

The A horizon, generally the plow layer, is 3 to 9 inches thick. It is very dark grayish-brown or dark grayish-brown silt loam or very fine sandy loam. The C horizon is dark grayish-brown or grayish-brown silt loam or very fine sandy loam. In most places, loamy sand is below a depth of 35 inches. The soils have slight or strong effervescence throughout the profile.

Haynie soils are associated with Eudora, Onawa, and Sarpy soils. They are more loamy than Onawa soils and have a thinner A horizon than Eudora soils. They contain less sand throughout the profile than Sarpy soils.

Haynie silt loam (0 to 1 percent slopes) (Hy).—This soil has the profile described as representative of the series. Included in mapping are small areas of Eudora soils and areas of soils that are sandy throughout.

Most crops respond well to fertilization. Applying farm manure or other sources of organic matter can also be beneficial. Soil blowing is a serious hazard, but it can be controlled by minimum tillage and stubble mulching, by growing a cover crop, or by a combination of those practices. This soil is suited to irrigation. It is rarely flooded. Capability unit I-1; woodland suitability group 2o1.

Judson Series

The Judson series consists of deep, nearly level, well-drained soils on low terraces and foot slopes along creeks. These soils formed in alluvium.

In a representative profile the surface layer is silt loam about 30 inches thick. It is very dark grayish brown in the upper 20 inches and dark brown in the lower 10 inches. The subsoil is about 20 inches of brown and dark-brown, friable silty clay loam. The underlying material is mottled brown silt loam.

Judson soils have high natural fertility and organic-matter content. Available water capacity is very high, and permeability is moderate. The surface layer is neutral or slightly acid, and the subsoil is medium acid or slightly acid. The soils are rarely flooded.

The native vegetation is tall grasses. These soils are cultivated, and the main crops are corn, soybeans, and grain sorghum. The soils are well suited to truck farming.

Representative profile of Judson silt loam, in a cultivated field, 2,600 feet north and 800 feet east of the southwest corner of sec. 11, T. 9 S., R. 22 E., about one-half mile southwest of Leavenworth, Leavenworth County:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; friable, slightly hard; plentiful fine roots; few worm casts; slightly acid; abrupt, smooth boundary.

A12—8 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard; few fine roots; few worm casts and channels; slightly acid; gradual, smooth boundary.

A3—20 to 30 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; moderate, fine, granular structure;

friable; slightly hard; few fine roots; common, grayish-brown (10YR 5/2) silt coats on ped surfaces; few worm casts; slightly acid; gradual, smooth boundary.

B2—30 to 50 inches, brown (10YR 4/3) and dark-brown (10YR 3/3) light silty clay loam, pale brown (10YR 6/3) dry; weak, fine and medium, subangular blocky structure; friable, slightly hard; few fine roots; common grayish-brown (10YR 5/2) silt coats on ped surfaces; medium acid; gradual, smooth boundary.

C—50 to 70 inches, brown (10YR 5/3) heavy silt loam, pale brown (10YR 6/3) dry; few, fine, faint, yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky structure; friable, slightly hard; common grayish-brown (10YR 5/2) silt coatings on ped surfaces; slightly acid.

The solum ranges from 40 to 60 inches in thickness. The A horizon is very dark brown or very dark grayish-brown silt loam or light silty clay loam. In places yellowish-brown and strong-brown mottles are below a depth of 30 inches.

Judson soils are associated with Kennebec and Bremer soils. They have higher chroma and contain more clay between depths of 20 to 40 inches than Kennebec soils. They have less clay in the B2 horizon than Bremer soils.

Judson silt loam (0 to 1 percent slopes) (JU).—This soil is on low terraces and foot slopes adjacent to major creeks. Included in mapping are small areas of Bremer and Kennebec soils.

This soil is well suited to corn, soybeans, and grain sorghum. It is also well suited to truck crops and orchards, and it can be irrigated. Some areas are leveled. Water from the creeks is used for irrigation in most places. Most crops respond well to fertilization. Capability unit I-1; woodland suitability group 2o1.

Kennebec Series

The Kennebec series consists of deep, nearly level, moderately well drained soils on bottom land. These soils formed in silty alluvium.

In a representative profile the surface layer is silt loam about 45 inches thick. It is very dark brown in the upper 20 inches and very dark grayish brown in the lower 25 inches. The underlying material is dark grayish-brown silty clay loam.

Kennebec soils have high organic-matter content and natural fertility. Available water capacity is very high, and permeability is moderate. These soils are sometimes flooded during the growing season.

The native vegetation is tall grasses and deciduous trees. Soybeans, grain sorghum, and corn are the main crops.

Representative profile of Kennebec silt loam, in a cultivated field, 500 feet north and 400 feet east of center of sec. 17, T. 9 S., R. 21 E., Leavenworth County:

Ap—0 to 6 inches, very dark brown (10YR 2/2) heavy silt loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; friable, slightly hard; plentiful fine and medium roots; common worm casts and channels; neutral; abrupt, smooth boundary.

A12—6 to 20 inches, very dark brown (10YR 2/2) heavy silt loam, very dark gray (10YR 3/1) dry; moderate to weak, fine, granular structure; friable, slightly hard; plentiful fine and medium roots; common worm casts and channels; neutral; diffuse, smooth boundary.

A13—20 to 45 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) dry; weak, fine and medium, granular structure; friable, slightly hard; few fine roots; few worm casts; some fine sand; neutral; diffuse, smooth boundary.

C—45 to 72 inches, dark grayish-brown (10YR 4/2) light silty

clay loam, grayish brown (10YR 5/2) dry; weak, coarse, prismatic structure; friable, slightly hard; slightly acid.

The A horizon is silt loam or silty clay loam. It is black, very dark gray, or very dark grayish brown. The C horizon is dark gray or very dark grayish brown. In places the C horizon is underlain by clayey material below a depth of 40 inches. Reaction is neutral or slightly acid throughout.

Kennebec soils are associated with Bremer, Eudora, Judson, Wabash, and Zook soils. They contain less clay throughout than Bremer, Wabash, or Zook soils. They have a thicker, dark-colored A horizon than Eudora soils and contain less coarse silt. They have less clay and lower chroma between depths of 20 to 40 inches than Judson soils.

Kennebec silt loam (0 to 1 percent slopes) (Ke).—This soil is on natural levees of Stranger Creek and low bottoms of other creeks. Included in mapping are small areas of Bremer and Wabash soils. Also included are narrow channels and wet areas.

If adequately fertilized, this soil is suited to most crops grown in the county. Flooding is a hazard, but in most years it is not of long enough duration to damage crops. Providing protection from flooding generally is not feasible. This soil is suited to tame grasses. The channel areas and wet places provide habitat for wildlife or are used for woodland. Capability unit IIw-2; woodland suitability group 3w2.

Knox Series

The Knox series consists of deep, strongly sloping to steep, well-drained soils on uplands. These soils are in strongly dissected areas along the Missouri River. They formed in loess.

In a representative profile the surface layer is about 6 inches of dark-brown silt loam (fig. 9). The subsoil is friable silty clay loam to a depth of 60 inches. The upper part is dark yellowish brown. The lower part is yellowish brown.

Knox soils have high available water capacity, moderate permeability, and medium natural fertility. They are medium acid to slightly acid throughout. Lime is beneficial to most crops, especially legumes. Most crops respond well to fertilization.

The native vegetation is timber, and the principal trees are oak, hickory, and walnut. Wheat and grain sorghum are the main crops. Orchards, hay, tame pasture, and woodland are well suited.

Representative profile of Knox silt loam in a cultivated field, 2,000 feet west and 800 feet north of southeast corner of sec. 11, T. 10 S., R. 23 E., about 1 mile southwest of Wolcott, Wyandotte County:

Ap—0 to 6 inches, dark-brown (10YR 3/3) silt loam, brown (10YR 5/3) dry; weak, fine, granular structure; friable, slightly hard; plentiful fine roots; common worm casts; slightly acid; abrupt, smooth boundary.

B21t—6 to 14 inches, dark yellowish-brown (10YR 4/4) silty clay loam, light yellowish brown (10YR 6/4) dry; moderate, fine, subangular and angular blocky structure; friable, hard; few fine roots; grayish-brown (10YR 5/2) silt coatings on ped surfaces; slightly acid; clear, smooth boundary.

B22t—14 to 23 inches, dark yellowish-brown (10YR 4/4) light silty clay loam, light yellowish brown (10YR 6/4) dry; weak, medium and fine, subangular blocky structure; friable, slightly hard; few fine roots, many open pores; slightly acid; gradual, smooth boundary.

B31t—23 to 39 inches, dark yellowish-brown (10YR 4/4) light silty clay loam, light yellowish brown (10YR 6/4) dry; weak, coarse, blocky structure; friable, slightly hard;

few fine roots; many open pores; slightly acid; gradual, smooth boundary.

B32—39 to 60 inches, yellowish-brown (10YR 5/4) light silty clay loam, very pale brown (10YR 7/4) dry; weak, coarse, prismatic structure; friable, slightly hard; few fine roots; few, fine, faint, yellowish-brown (10YR 5/6) and grayish-brown (10YR 5/2) mottles in lower part; slightly acid.

The solum ranges from 36 to more than 60 inches in



Figure 9.—Profile of Knox silt loam showing prismatic structure and loess parent material.

thickness. The A1 or Ap horizon is 6 to less than 10 inches thick. It is very dark brown to dark brown silt loam. The B2t horizon is yellowish brown or dark yellowish brown. The B3 or C horizon is silt loam or light silty clay loam over silty material that in places has a hue of 7.5YR below a depth of 50 inches.

Mapping unit Km has a slightly browner surface layer than is defined as the range for the series, but this difference does not alter the use or behavior of the soil.

Knox soils are associated with Ladoga and Marshall soils. They have less clay in the B2t horizon than Ladoga soils and lack the thick, dark-colored A horizon that is typical of Marshall soils.

Knox silt loam, 7 to 12 percent slopes (Kh).—This soil is on the convex to concave sides and the long, narrow, sharply convex tops of ridges. It has the profile described as representative of the series. Included in mapping are small areas of Ladoga soils and small areas of eroded Knox soils and of Welda and Armster soils.

This Knox soil is cleared of timber. If cultivated, it is best suited to wheat and grain sorghum. It is well suited to orchards, hay, tame pasture, and woodland.

Erosion is a serious hazard in cultivated areas, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. In orchards a permanent grass cover is needed. Fertility and tilth can be maintained by growing green manure crops and legumes and applying farm manure. Stands of timber can be improved by selective cutting and thinning.

Tame grasses respond well to fertilization. Capability unit IVE-5; woodland suitability group 4o1.

Knox silt loam, 12 to 18 percent slopes (Kk).—This soil has irregular convex and concave slopes (fig. 10). Its profile is similar to that described as representative of the series, but the solum is less than 60 inches thick and the subsoil contains less clay.

Included with this soil in mapping is a soil similar to this Knox soil, but its subsoil contains less clay. Also included are spots of eroded soils at heads of drainageways.

Much of the acreage is cleared. The soil is best suited to tame pasture, which responds well to fertilization and can be kept vigorous under good grazing management. It is suited to small grain occasionally if it is farmed on the contour and residue is managed for erosion control. It is also suited to orchards and woodland. In orchards, a permanent grass cover is needed. In woodland, selective cutting and stand reduction are needed. Capability unit VIe-1; woodland suitability group 4r2.

Knox silty clay loam, 7 to 12 percent slopes, eroded (Km).—This soil is at the heads of drainageways and in areas where slopes are convex. Its profile is similar to the one described as representative of the series, but the surface layer contains more clay and is lighter colored.

Included with this soil in mapping are small areas of Armster, Ladoga, and Welda soils.



Figure 10.—Area of Knox silt loam, 12 to 18 percent slopes.

If cultivated, this Knox soil is best suited to wheat and grain sorghum. It is well suited to tame grass, orchards, and woodland. Fertility and organic-matter content are low, but they can be improved by applying fertilizer and organic matter. Tilth is poor, but it can be improved by growing green-manure crops and legumes and applying farm manure. Erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. In orchards, a permanent grass cover is needed.

Capability unit IVe-5; woodland suitability group 4o1.

Knox complex, 18 to 30 percent slopes (Kn).—This mapping unit is about 40 percent Knox soil, 25 percent a soil that is similar to Knox silt loam but is silt loam throughout, and 35 percent Sogn soil and the associated exposed limestone outcrop. These are steep, deep and shallow soils on dissected bluffs of the Missouri River. The Knox soil has a profile similar to the one described as representative of the series, but the subsoil is thinner and contains less clay. The Sogn soil has a profile similar to the one described as representative of the series, but the surface layer contains less clay and more silt.

Included with this complex in mapping are small areas of steep, deep and moderately deep loamy soils formed in glacial till.

This mapping unit is best suited to woodland and wildlife habitat. It is too steep for cultivation. Good woodland management, such as selective cutting and stand reduction, is needed. Capability unit VIIe-1; woodland suitability group 4r2.

Konawa Series

The Konawa series consists of deep, sloping to steep, well-drained soils on uplands. These soils formed in sandy eolian material.

In a representative profile the surface layer is about 4 inches of very dark grayish-brown fine sandy loam. The subsurface layer is brown fine sandy loam about 15 inches thick. The subsoil is about 28 inches of dark-brown, firm and friable clay loam. The underlying material is brown loam.

Konawa soils have low natural fertility and organic-matter content. Available water capacity is high, and permeability is moderate. The surface layer is slightly acid or medium acid. Lime is beneficial to most crops, especially legumes. Crops also respond well to fertilization.

The native vegetation is dominantly oak and hickory and an understory of tall grasses. Many areas are cleared of timber and are cultivated or in tame pasture. The main crops are wheat and grain sorghum.

Representative profile of Konawa fine sandy loam, 3 to 8 percent slopes, in tame pasture, 800 feet east and 200 feet north of southwest corner of sec. 16, T. 12 S., R. 22 E., about 4 miles east of Linwood, Leavenworth County:

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; very friable, slightly hard; abundant fine and medium roots; slightly acid; clear, smooth boundary.

A2—4 to 19 inches, brown (10YR 5/3) light fine sandy loam, light gray (10YR 7/2) dry; weak, fine, granular structure; very friable, slightly hard; plentiful fine roots; slightly acid; clear, smooth boundary.

B21t—19 to 26 inches, dark-brown (7.5YR 4/4) heavy clay loam, brown (7.5YR 5/4) dry; weak, coarse, blocky structure; firm, hard; plentiful fine roots; few streaks of brown (10YR 4/3); medium acid; gradual, smooth boundary.

B22t—26 to 39 inches, dark-brown (7.5YR 4/4) clay loam, brown (7.5YR 5/4) dry; weak, coarse, blocky structure; firm, hard; plentiful fine roots; few streaks of brown (10YR 4/3); medium acid; gradual, smooth boundary.

B3—39 to 47 inches, dark-brown (7.5YR 4/4) light clay loam, brown (7.5YR 5/4) dry; weak, coarse, blocky structure; friable, hard; strongly acid; gradual, smooth boundary.

C—47 to 60 inches, brown (7.5YR 5/4) loam, light brown (7.5YR 6/4) dry; massive; friable, slightly hard; strongly acid.

The solum ranges from 40 to 60 inches in thickness. The A1 horizon is less than 6 inches thick and is very dark grayish brown or dark grayish brown. It is medium acid or slightly acid. The A2 horizon is dark grayish-brown or brown fine sandy loam or loamy fine sand. The B2t horizon is dark-brown or reddish-brown clay loam or sandy loam. It is strongly acid or medium acid. The C horizon is loam or fine sandy loam.

Konawa soils are associated with Armster, Gymer, and Welda soils. They lack the glacial sand and gravel that is typical of Armster soils and have less clay in the B2t horizon. They have more sand in the A and B2t horizons than Gymer and Welda soils and, unlike Gymer soils, they have an A2 horizon.

Konawa fine sandy loam, 3 to 8 percent slopes (Ko).—This soil is on convex sides and tops of ridges. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Gymer, Ladoga, and Welda soils. Also included are soils that are sandy throughout and soils that are similar to this Konawa soil but have silty, reddish-brown soil material below a depth of 30 inches.

This soil is best suited to wheat and grain sorghum. It is also suited to tame pasture and woodland. Water erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Farm manure can be used to increase organic-matter content and maintain fertility. Tame pasture can be kept vigorous under good grazing management and adequate fertilization. Capability unit IIIe-4; woodland suitability group 4o1.

Konawa fine sandy loam, 8 to 20 percent slopes (Kw).—This soil is on the convex to concave sides and the tops of narrow ridges. It has a profile similar to that described as representative of the series, but in places the subsurface layer is thicker. In about 30 percent of the acreage, reddish-brown silty clay loam is at a depth of 25 to 35 inches and the clay loam B2t horizon is about 5 inches thick.

Included with this soil in mapping are small areas of Gymer and Welda soils. Also included are soils that are sandy throughout.

If cleared of timber, this soil is best suited to tame pasture. It is suited to woodland. Water erosion is a serious hazard, but it can be controlled by maintaining a permanent cover of vegetation. Tame pasture can be kept vigorous under adequate fertilization and good grazing management. Native timber can be

improved by such practices as thinning and selective cutting. Capability unit VIe-1; woodland suitability group 4r2.

Ladoga Series

The Ladoga series consists of deep, sloping, moderately well drained soils on uplands. These soils formed in loess.

In a representative profile the surface layer is about 7 inches of very dark grayish-brown silt loam (fig. 11). The subsoil is about 42 inches of firm and friable silty clay loam. It is dark brown in the upper 18 inches and mottled brown in the lower 24 inches. The underlying material is mottled grayish-brown silty clay loam.

Ladoga soils have high available water capacity, moderately slow permeability, and medium natural fertility. They are medium acid to neutral in the surface layer and strongly acid to slightly acid in the



Figure 11.—Profile of Ladoga silt loam.

subsoil. Most crops respond well to fertilization. Lime is beneficial to most crops, especially legumes.

Most of the acreage is cultivated. The principal crops are wheat and grain sorghum. Corn and soybeans are grown occasionally. The soils are suited to tame grass and woodland.

Representative profile of Ladoga silt loam, 4 to 7 percent slopes, in a cultivated field, 1,600 feet south and 900 feet west of northeast corner of sec. 29, T. 8 S., R. 22 E., Leavenworth County:

- Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, grayish brown (10YR 5/2) dry; weak, thin, platy parting to weak, fine, granular structure; friable, slightly hard; few fine roots; neutral; abrupt, smooth boundary.
- B21t—7 to 15 inches, dark-brown (10YR 4/3) heavy silty clay loam, brown (10YR 4/3) crushed, brown (10YR 5/3) dry; dark yellowish-brown (10YR 3/4) coatings on peds; moderate, fine, angular and subangular blocky structure; firm, hard; few fine roots; few silt coatings on peds; distinct, continuous clay films; strongly acid; clear, smooth boundary.
- B22t—15 to 25 inches, dark-brown (10YR 4/3) heavy silty clay loam, brown (10YR 4/3) crushed, brown (10YR 5/3) dry; dark yellowish-brown (10YR 3/4) coatings on peds; moderate, medium and fine, subangular blocky structure; firm, hard; weak, thin, continuous clay films; few fine roots; few, small, round, black spots; strongly acid, gradual, smooth boundary.
- B23t—25 to 40 inches, brown (10YR 5/3) silty clay loam, pale brown (10YR 6/3) dry; brown (10YR 4/3) coatings on peds; few, fine, distinct, grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky parting to weak, medium, subangular blocky structure; firm, hard; few, small, black spots; weak, continuous clay films; many open pores; slightly acid; gradual, smooth boundary.
- B3—40 to 49 inches, brown (10YR 5/3) and grayish-brown (10YR 5/2) silty clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky structure; friable, hard; weak, discontinuous clay films; common open pores; slightly acid; gradual, smooth boundary.
- C—49 to 60 inches, grayish-brown (10YR 5/2) light silty clay loam, light brownish gray (10YR 6/2) dry; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure; friable, slightly hard; many open pores; neutral.

The solum ranges from 36 to 60 inches in thickness. The Ap horizon is very dark grayish-brown or dark-brown silt loam, but it is silty clay loam in places. The B21t and B22t horizons are heavy silty clay loam or light silty clay.

Ladoga soils are associated with Armster, Knox, Sharpsburg, and Welda soils. They contain less sand throughout the solum than Armster soils, which formed in glacial till. They have more clay in the B2t horizon than Knox soils and lack the hues of 7.5YR and 5YR in the B2t horizon that are typical of Welda soils. They lack the thick, dark-colored A1 and B1 horizons typical of Sharpsburg soils.

Ladoga silt loam, 4 to 7 percent slopes (La).—This soil is on the broad convex tops of ridges and in places on the concave sides. Included in mapping are small areas of Knox and Sharpsburg soils. Also included are spots of eroded soils.

This soil is best suited to wheat and grain sorghum. Only a limited acreage is in corn and soybeans. The soil is also suited to tame pasture and woodland.

Water erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Farm manure is beneficial in maintaining organic-matter content. Fertility and tilth can be improved or maintained by growing legumes

and green manure crops and applying farm manure. Capability unit IIIe-3; woodland suitability group 401.

Marshall Series

The Marshall series consists of deep, gently sloping to moderately steep, well-drained soils on uplands. These soils formed in loess.

In a representative profile the surface layer is about 18 inches thick. It is very dark brown silt loam in the upper 13 inches and very dark grayish-brown or dark-brown light silty clay loam in the lower 5 inches. The subsoil is about 28 inches of friable silty clay loam. It is brown in the upper 9 inches, mottled dark brown in the next 10 inches, and mottled yellowish brown in the lower 9 inches. The underlying material is mottled yellowish-brown silt loam.

Marshall soils have high fertility and organic-matter content. They are friable and easily worked. Available water capacity is very high, and permeability is moderate. The surface layer and subsoil are slightly acid or medium acid. Lime is beneficial to most crops. All crops respond well to fertilization.

Most of the acreage is cultivated, and the soils are well suited to all cultivated crops grown in the county. The main crops are corn and soybeans. The soils are also well suited to orchards, truck farming, and tame pasture. The native vegetation is tall prairie grasses.

Representative profile of Marshall silt loam, 4 to 9 percent slopes, in a cultivated field, 1,950 feet north and 1,900 feet west of southeast corner sec. 9, T. 8 S., R. 22 E., about 2.5 miles south of Kickapoo, Leavenworth County:

- Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; friable, slightly hard; plentiful fine roots; common worm casts; slightly acid; abrupt, smooth boundary.
- A12—7 to 13 inches, very dark brown (10YR 2/2) heavy silt loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard; plentiful fine roots; common worm casts; slightly acid; clear, smooth boundary.
- A3—13 to 18 inches, very dark grayish-brown (10YR 3/2) and dark-brown (10YR 4/3) light silty clay loam; moderate, fine and very fine, subangular blocky structure; friable, hard; few fine roots; common worm casts; medium acid; clear, smooth boundary.
- B21—18 to 27 inches, brown (10YR 4/3) medium silty clay loam, yellowish brown (10YR 5/4) dry; dark-brown (10YR 3/3) coatings on peds; moderate, fine, subangular blocky structure; friable, hard; few fine roots; few worm casts; medium acid; gradual, smooth boundary.
- B22—27 to 37 inches, dark-brown (10YR 4/3) medium silty clay loam, light yellowish brown (10YR 6/4) dry; few, fine, faint, yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky parting to moderate, fine and medium, subangular blocky structure; friable, hard; few fine roots; few worm casts; medium acid; gradual, smooth boundary.
- B3—37 to 46 inches, yellowish-brown (10YR 5/4) light silty clay loam, light yellowish brown (10YR 6/4) dry; common, fine, distinct, grayish-brown (10YR 5/2) mottles and fine, faint, yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky parting to weak, medium and fine, subangular blocky structure; friable, slightly hard; few fine roots; many open pores; slightly acid; gradual, smooth boundary.
- C—46 to 65 inches, yellowish-brown (10YR 5/4) heavy silt

loam, light yellowish brown (10YR 6/4) dry; common, fine, distinct, grayish-brown (10YR 5/2) mottles; weak, coarse, prismatic structure; friable, slightly hard; many open pores; slightly acid.

The solum ranges from 40 to 60 inches in thickness. The Ap and A12 horizons are generally silt loam, but they are silty clay loam in places. The B2 horizons are dark brown or brown.

Marshall soils are associated with Knox and Sharpsburg soils. They have a thicker, dark-colored A horizon than Knox soils. They have less clay in the B2 horizon than Sharpsburg soils.

Marshall silt loam, 1 to 4 percent slopes (Mb).—This soil is on broad ridgetops and concave foot slopes. It has a profile similar to that described as representative of the series, but the surface layer is about 5 inches thicker and the subsoil contains more clay. Included in mapping are small areas of Sharpsburg soils.

This soil is well suited to corn and soybeans. It is also well suited to orchards and truck farming. Erosion is a hazard, but it can be controlled by contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Capability unit IIe-1; not assigned to a woodland suitability group.

Marshall silt loam, 4 to 9 percent slopes (Mc).—This soil has convex and concave slopes. It has the profile described as representative of the series. Included in mapping are small areas of Sharpsburg soils.

This soil is well suited to corn, soybeans, and grain sorghum. It is also suited to orchards and tame pasture. Erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. In orchards the soil can be protected by terraces or by permanent grass cover. Capability unit IIIe-1; not assigned to a woodland suitability group.

Marshall silt loam, 9 to 15 percent slopes (Md).—This soil has irregular slopes. It has a profile similar to that described as representative of the series, but the surface layer is about 5 inches thinner and the subsoil is thinner and contains less clay. Included in mapping are small areas of Knox soils.

Because erosion is a serious hazard, this soil is best suited to tame pasture and wheat and, to a lesser extent, to corn, soybeans, and grain sorghum. If cultivated, erosion can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. This soil is suited to orchards. Tame pasture can be kept vigorous under good grazing management and adequate fertilization. Capability unit IVe-1; not assigned to a woodland suitability group.

Martin Series

The Martin series consists of deep, sloping to strongly sloping, moderately well drained soils that have a very firm clayey subsoil. These soils are on uplands. They formed in residuum from weathered shale.

In a representative profile the surface layer is about 8 inches of very dark brown silty clay loam. The subsoil is mottled very firm silty clay about 47 inches

thick. The upper 7 inches of the subsoil is black; the middle 9 inches is very dark grayish brown and has hard round black concretions; and the lower 31 inches is dark grayish brown and has black concretions. The underlying material is mottled silty clay loam.

Martin soils have high natural fertility, moderate available water capacity, and slow permeability. The surface layer is medium acid or slightly acid, and the subsoil is medium acid to neutral. Lime is beneficial to most crops, especially legumes. Crops also respond well to fertilization.

Most of the acreage is cultivated, and the main crops are grain sorghum, wheat, corn, and soybeans. These soils are suited to hay and tame pasture. Alfalfa grows especially well because moisture from the higher, steeper slopes tends to subirrigate the soil.

Representative profile of Martin silty clay loam, 4 to 7 percent slopes, in tame pasture, 1,400 feet south and 400 feet east of northwest corner of sec. 10, T. 12 S., R. 20 E., Leavenworth County:

- Ap—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) dry; moderate, fine and medium, granular structure; firm, hard; plentiful fine roots; few shale fragments; slightly acid; abrupt, smooth boundary.
- B21t—8 to 15 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate, medium, angular and subangular structure; very firm, very hard; plentiful fine roots; few, hard, round, black concretions; slightly acid; clear, smooth boundary.
- B22t—15 to 24 inches, very dark grayish-brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; common, fine, faint, brown (7.5YR 4/4) mottles; weak, coarse, blocky parting to weak, fine and medium, subangular blocky structure; very firm, very hard; few fine roots; common, hard, round, black concretions; few weathered shale fragments; slightly acid; gradual, smooth boundary.
- B3t—24 to 55 inches, dark grayish-brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; many, fine, faint and distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, blocky structure; very firm, very hard; few fine roots; common, hard, round, black concretions; neutral; diffuse, smooth boundary.
- C—55 to 75 inches, grayish-brown (2.5Y 5/2) heavy silty clay loam, light brownish gray (2.5Y 6/2) dry; many, fine, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; massive; firm, very hard; few, hard, round, black concretions; neutral.

The solum ranges from 40 to more than 60 inches in thickness. The A horizon is generally black or very dark brown silty clay loam, but it is silt loam in places. The B2t horizon has hue of 7.5YR in places.

Martin soils are associated with Elmont, Gosport, Grundy, Haig, Sogn, and Oska soils. They contain more clay in the B2t horizon than Elmont soils. They have a more dense subsoil than Grundy soils and, unlike these soils, formed in material derived from shale instead of in loess. They have a thicker, more clayey B2t horizon than Oska soils. Martin soils have a less dense and compact B2t horizon than Haig soils and have a thicker, dark-colored A1 horizon than Gosport soils. They are deeper than Sogn soils and, unlike these soils, formed in residuum from shale instead of limestone.

Martin silty clay loam, 4 to 7 percent slopes (Mn).—This soil is on the convex to concave sides of small drainageways and below areas of outcrops of interbedded shale and limestone. It has the profile described as representative of the series. Included in mapping are small areas of Elmont and Grundy soils.

This soil is best suited to wheat, grain sorghum, and alfalfa. Only a limited acreage is in corn and soybeans. The soil is well suited to tame grass, which responds well to fertilization. It can be used to grow trees and shrubs that provide wildlife habitat.

Erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Capability unit IIIe-2; not assigned to a woodland suitability group.

Martin silty clay loam, 7 to 12 percent slopes (Mr).—This soil is below areas of outcrops of interbedded shale and limestone. It has a profile similar to that described as representative of the series, but the surface layer is about 4 inches thinner and the subsoil is thinner. Included in mapping are small areas of Elmont soils and eroded Martin and Elmont soils.

Most of the acreage is used for tame pasture and hay. A few areas are cultivated. If erosion is controlled by contour farming, minimum tillage, and stubble mulching, or by a combination of those practices, this soil is suited to wheat or other small grain and to an occasional crop of grain sorghum. Maintaining soil tilth, fertility, and organic-matter content is essential. Green manure crops and legumes and farm manure are needed. Grasses can be kept vigorous under adequate fertilization and good grazing management. Capability unit IVe-2; not assigned to a woodland suitability group.

Martin soils, 6 to 12 percent slopes, eroded (Ms).—This soil is on the convex to concave sides of small drainageways and below areas of outcrops of interbedded shale and limestone. It has a profile similar to that described as representative of the series, but the original surface layer has been removed by erosion and the present surface layer has more clay and generally is lighter colored. The surface layer is silty clay loam or silty clay. Gullies are common.

Included with this soil in mapping are small areas of eroded Elmont, Grundy, and Vinland soils. Also included are slickspots in places.

This soil is best suited to tame grasses. Tame pasture can be kept vigorous under adequate fertilization and good grazing management. Capability unit VIe-1; not assigned to a woodland suitability group.

Onawa Series

The Onawa series consists of deep, calcareous, nearly level, somewhat poorly drained soils on bottom land along the Missouri River. These soils are moderately alkaline. They formed in fine-textured and medium-textured alluvium.

In a representative profile (fig. 12) the surface layer is about 6 inches of black silty clay loam. The next layer is very firm silty clay about 19 inches thick. The upper 13 inches is very dark gray and dark gray mottled with strong brown and yellowish red, and the lower 6 inches is dark grayish brown mottled with strong brown and yellowish brown. The underlying material is grayish-brown coarse silt loam mottled with yellowish brown and strong brown.

Onawa soils have high natural fertility and organic-matter content. Permeability is slow in the upper part and moderately rapid in the lower part.

Available water capacity is high. Runoff is slow. In some years it ponds after heavy rains and damages crops. Flooding is a hazard, but most areas are protected by dikes. No lime is required.

The native vegetation is mostly willow and cottonwood trees. Most areas are cleared of timber. Soy-

beans, grain sorghum, and corn are the main crops.

Representative profile of Onawa silty clay loam (0 to 1 percent slopes), in a cultivated field, 1,400 feet east and 1,700 feet north of southwest corner of sec. 34, T. 7 S., R. 22 E., about 1 mile southeast of Kickapoo, Leavenworth County:

Ap—0 to 6 inches, black (10YR 2/1) heavy silty clay loam, dark gray (10YR 4/1) dry; weak, fine, granular structure; firm, hard; few fine roots; moderately alkaline; abrupt boundary.

C1—6 to 19 inches, very dark gray (10YR 3/1) silty clay mixed with strata of dark gray (10YR 4/1) and dark grayish brown (10YR 4/2); common, fine, distinct, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/6) mottles; moderate, medium, angular structure; few layers massive; very firm, very hard; few fine roots; slight effervescence; moderately alkaline; clear, wavy boundary.

C2—19 to 25 inches, dark grayish-brown (10YR 4/2) silty clay that has a thin layer of very dark gray (10YR 3/1); common, fine, distinct, strong-brown (7.5YR 5/6) and yellowish-brown (10YR 5/6) mottles; massive and weak to moderate, medium, angular and subangular blocky structure; thin strata of coarse silt loam; very firm, very hard; slight effervescence; moderately alkaline; clear, wavy boundary.

IIC—25 to 60 inches, grayish-brown (10YR 5/2) coarse silt loam, light brownish gray (10YR 6/2) dry; many, common, fine, faint and distinct, dark yellowish-brown (10YR 4/4) and strong-brown (7.5YR 5/6) mottles; massive; friable, slightly hard; thin clayey and sandy strata; strong effervescence; moderately alkaline.

The Ap horizon is generally black or very dark gray silty clay loam, but in places it is light silty clay. The A and C horizons, which correspond to the fine-textured part of the profile, range from 20 to 38 inches in total thickness. The C horizon has common or many yellowish-brown, strong-brown, and yellowish-red mottles, and thin strata of darker colored and more loamy material are common. The IIC horizon is grayish-brown or brown coarse silt loam or very fine sandy loam commonly mottled with brown, yellowish brown, and strong brown. In places it is underlain by loamy sand below a depth of 40 inches.

Onawa soils are associated with Eudora, Haynie, and Wabash soils. They have less sand in the A and C horizons than Eudora and Haynie soils. They have a thinner clayey solum than Wabash soils, which are clayey throughout. Also in contrast with those soils, they are calcareous and are underlain by loamy alluvium.

Onawa silty clay loam (0 to 1 percent slopes) (On).—This soil has the profile described as representative of the series. Included in mapping are small areas of Haynie soils.

Wetness is the major limitation. If adequately fertilized and drained, this soil is suited to most crops grown in the survey area. Bedding and ditches can be used for drainage. Capability unit IIw-1; woodland suitability group 4w2.

Onawa soils, overwash (0 to 1 percent slopes) (Oo).—These soils are along the Missouri River, where a 6- to 20-inch layer of sandy and loamy overwash was deposited during a rare major flood. In most places the overwash was deposited uniformly over the area, but in places the Onawa soils in this mapping unit occur as a series of alternate, narrow bands with Onawa silty clay loam. Through deep plowing and normal tillage, the overwash layer has been mixed with the underlying material, and the present surface layer is silty clay loam, clay loam, fine sandy loam, silt loam, loam, or loamy sand. Except for the surface layer these soils have a profile similar to the one described as representative of the series.

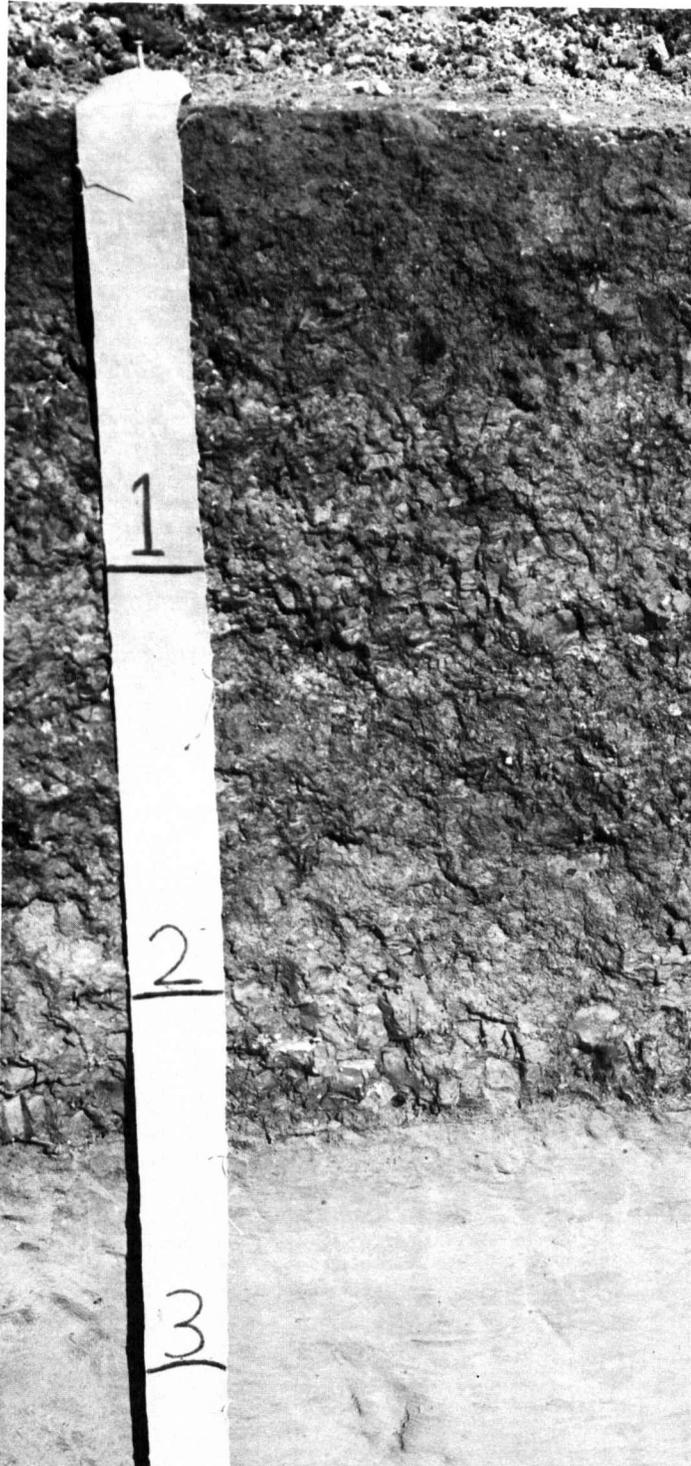


Figure 12.—Profile of Onawa silty clay loam.

Included with these soils in mapping are small areas of Onawa silty clay loam and Haynie soils. Some wet spots and sandy spots are also included.

These soils are well suited to most crops grown in the survey area. Wetness is not a serious limitation in most places; therefore, crops can be planted earlier and tillage is less difficult. Soil blowing is a hazard in some years. It can be controlled by such practices as stubble mulching and minimum tillage. Capability unit IIw-1; woodland suitability group 4w2.

Oska Series

The Oska series consists of moderately deep, sloping, well-drained soils that have a reddish-brown subsoil. These soils are on uplands. They formed in residuum from limestone or calcareous shale.

In a representative profile the surface layer is about 9 inches of very dark brown silty clay loam. The subsoil is about 29 inches thick. It is dark-brown firm silty clay loam in the upper part and reddish-brown firm heavy silty clay loam in the lower part. Limestone is at a depth of 38 inches.

Oska soils have moderate available water capacity and slow permeability. They are medium acid to slightly acid throughout. Lime is beneficial to most crops. Crops also respond well to fertilizer.

Most of the acreage is cultivated. The soils are well suited to tame grass and hay. If cultivated, they are best suited to wheat and grain sorghum. Corn or soybeans can be grown occasionally.

Representative profile of Oska silty clay loam, 3 to 8 percent slopes, in tame pasture, 1,600 feet east and 300 feet south of the center of sec. 25, T. 9 S., R. 20 E., Leavenworth County:

- A1—0 to 9 inches, very dark brown (10YR 2/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, fine and medium, granular structure; friable, hard; plentiful fine roots; few worm casts; medium acid; clear, smooth boundary.
- B1—9 to 15 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/3) dry; moderate, fine and very fine, subangular blocky structure; firm, hard; few fine roots; few worm casts; medium acid; clear, smooth boundary.
- B21t—15 to 28 inches, reddish-brown (5YR 4/3) heavy silty clay loam, reddish brown (5YR 5/3) dry; dark reddish-brown (5YR 3/3) and dark-brown (7.5YR 3/2) surfaces on peds; moderate, medium and fine, subangular blocky structure; firm, hard; few fine roots; thin, continuous clay films; few chert fragments; medium acid; gradual, smooth boundary.
- B22t—28 to 38 inches, reddish-brown (5YR 4/3) and yellowish-red (5YR 4/6) heavy silt clay loam; dark reddish-gray (5YR 4/2) surfaces on peds; moderate, medium and fine, subangular blocky structure; firm, hard; common manganese concretions and spots; common chert fragments; slightly acid; clear, smooth boundary.
- R—38 inches, limestone.

The solum ranges from 20 to 40 inches in thickness and corresponds to the depth to limestone. The B horizon ranges from dark-brown to reddish-brown silty clay loam or silty clay.

Oska soils are associated with Martin, Sharpsburg, and Sogn soils. They have a browner B2t horizon than Martin and Sharpsburg soils and are shallower over rock. They have a thicker solum than Sogn soils and, unlike those soils, have hues of 7.5YR and 5YR, instead of 10YR.

Oska silty clay loam, 3 to 8 percent slopes (Os).—This soil is above areas of limestone outcrops. Slopes

are convex. Included in mapping are small areas of a soil that is similar to this Oska soil but is more than 40 inches deep over limestone. Also included are small areas of Grundy, Martin, Pawnee, and Sharpsburg soils.

Erosion is a serious hazard, but it can be controlled by terraces, contour farming, or residue management, or by a combination of those practices. Tilth, fertility, and organic-matter content can be maintained by growing green manure crops and legumes and applying farm manure. Capability unit IIIe-5; not assigned to a woodland suitability group.

Pawnee Series

The Pawnee series consists of deep, gently sloping to sloping, moderately well drained soils on uplands. These soils formed in moderately fine textured glacial till.

In a representative profile (fig. 13) the surface layer is about 8 inches of very dark brown clay loam. The subsoil is about 41 inches thick. It is very dark grayish-brown, firm clay loam in the upper 4 inches; dark grayish-brown and yellowish-brown, very firm clay mottled with yellowish red and strong brown in the middle 14 inches; and grayish-brown and yellowish-brown, firm clay and clay loam in the lower 23 inches. The underlying material is calcareous, grayish-brown and yellowish-brown clay loam.

Pawnee soils have high available water capacity and slow permeability. They are medium acid or slightly acid in the surface layer and upper part of the subsoil. Lime is beneficial to most crops, especially legumes.

Most of the acreage has been cultivated, but now much of it is used for tame pasture. If well managed, these soils are suited to most crops commonly grown in the counties. The native vegetation is tall grasses.

Representative profile of Pawnee clay loam, 4 to 8 percent slopes, in a cultivated field, 2,300 feet west and 700 feet south of the northeast corner of sec. 10, T. 10 S., R. 20 E., Leavenworth County:

- Ap—0 to 8 inches, very dark brown (10YR 2/2) light clay loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard; abundant fine and medium roots; few worm casts; slightly acid; abrupt, smooth boundary.
- B1—8 to 12 inches, very dark grayish-brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) dry; common, fine, distinct, dark-brown (7.5YR 4/4) mottles; moderate, fine, subangular and angular blocky structure; firm, hard; plentiful fine roots; common pebbles; medium acid; clear, smooth boundary.
- B21t—12 to 19 inches, dark grayish-brown (10YR 4/2) clay, light brownish gray (10YR 6/2) dry; common, fine, distinct, yellowish-red (5YR 4/6) and strong-brown (7.5YR 5/6) mottles; dark-colored coatings on peds; moderate, fine and medium, subangular and angular blocky structure; very firm, very hard; plentiful fine roots; common pebbles; medium acid; gradual, smooth boundary.
- B22t—19 to 26 inches, yellowish-brown (10YR 5/4) clay, light yellowish brown (10YR 6/4) dry; common fine, distinct, yellowish-red (5YR 4/6) and strong-brown (7.5YR 5/6) mottles; weak to medium, angular and subangular blocky structure; very firm, very hard; few roots; many pebbles; much fine sand and gravel; slightly acid; gradual, smooth boundary.
- B23t—26 to 36 inches, mixed grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) clay; weak, coarse,

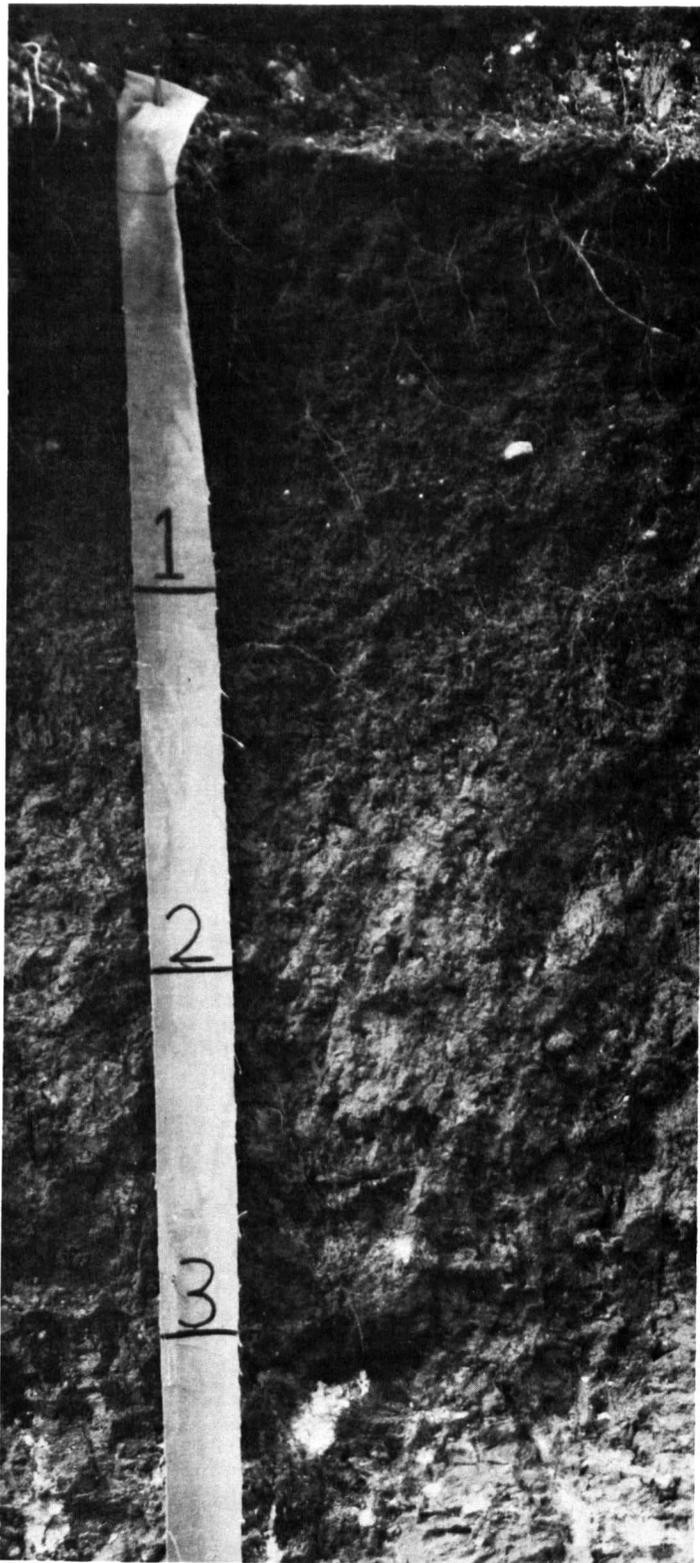


Figure 13.—Profile of Pawnee clay loam showing calcaireous underlying material.

blocky structure; firm, hard; few fine roots; common, soft, black concretions; slightly acid; diffuse, smooth boundary.

B3—36 to 49 inches, mixed grayish-brown (2.5Y 5/2), yellowish-brown (10YR 5/6), and light olive-brown (2.5Y 5/4) clay loam; weak, coarse, blocky structure; firm, hard; few fine roots; common pebbles; neutral; diffuse smooth boundary.

C—49 to 60 inches, mixed grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) clay loam; weak, coarse, blocky structure; firm, hard; common pebbles; mildly calcareous; common soft and semihard lime spots and concretions; moderately alkaline.

The solum ranges from 40 to 60 inches in thickness. The A horizon is very dark brown or very dark grayish brown. The B2t horizon generally is clay, but in places it is clay loam. Soft spots and concretions of segregated calcium carbonate typically are below a depth of 40 inches.

Mapping unit Pe has a browner surface layer than is defined as the range for the series, but this difference does not alter the use or behavior of the soil.

Pawnee soils are associated with Armster, Grundy, Sharpsburg, and Shelby soils. They have a thicker, dark-colored A horizon than Armster soils and, unlike those soils, lack an A2 horizon. They contain more glacial sand and gravel throughout than Grundy and Sharpsburg soils, both of which formed in loess. They have more clay in the B2t horizon than Shelby soils.

Pawnee clay loam, 1 to 4 percent slopes (Pb).—This soil is on ridgetops. It has a profile similar to that described as representative of the series, but the surface layer is about 5 inches thicker and the subsoil is thicker and contains more clay. In places the surface layer contains more silt. Included in mapping are small areas of Grundy and Shelby soils.

This soil is best suited to wheat, grain sorghum, and soybeans. Corn can be grown occasionally. The soil is well suited to tame pasture. Erosion is a hazard, but it can be controlled by contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Maintaining fertility and tilth is essential. Capability unit IIe-2; not assigned to a woodland suitability group.

Pawnee clay loam, 4 to 8 percent slopes (Pc).—This soil has convex to concave slopes. It has the profile described as representative of the series. Included in mapping are small areas of Grundy, Oska, and Shelby soils and spots of eroded Pawnee soils. Wet and seepy spots are common at the boundary between Grundy and Pawnee soils.

This soil is best suited to grain sorghum and wheat. Corn and soybeans can be grown occasionally. Much of the acreage is used for hay and tame pasture.

Erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching or by a combination of those practices. Growing green manure and legumes and applying fertilizer and farm manure helps in maintaining tilth and fertility. Wet and seepy spots can be tile drained. Tame pasture can be kept vigorous under additions of fertilizer and lime and good grazing management. Capability unit IIIe-2; not assigned to a woodland suitability group.

Pawnee clay loam, 4 to 8 percent slopes, eroded (Pe).—This soil has convex to concave slopes, generally at the heads of drainageways. It has a profile similar to that described as representative of the series, but the original surface layer has been thinned by erosion and now is browner and contains more

clay because it has been mixed with the subsoil. In many places, small gullies have formed.

Included with this soil in mapping are small areas of eroded Grundy, Oska, and Shelby soils. Wet and seepy spots are common at the boundary between Grundy and Pawnee soils.

This soil is best suited to small grain, hay, and tame pasture. Row crops can be grown occasionally. Erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Applying farm manure and growing legumes help in maintaining fertility and tilth.

Tame pasture can be kept vigorous under proper fertilization and good grazing management. Capability unit IVe-4; not assigned to a woodland suitability group.

Sarpy Series

The Sarpy series consists of deep, nearly level to undulating, excessively drained soils on bottom land along the rivers. These soils formed in sandy alluvium.

In a representative profile the surface layer is about 9 inches of dark grayish-brown loamy fine sand. The underlying material to a depth of 60 inches is light brownish-gray fine sand.

Sarpy soils have low available water capacity and very rapid permeability. Fertility and organic-matter content are low. Crops respond well to fertilizer. The soils are neutral to mildly alkaline throughout.

Most of the acreage is cultivated, and the principal crops are legumes and small grain. If fertility and organic-matter content can be improved by growing legumes and green-manure crops and applying farm manure, these soils are used for truck crops. Part of the acreage is wooded. The native vegetation is deciduous trees, such as willow and cottonwood.

Representative profile of Sarpy loamy fine sand in an area of Sarpy-Haynie complex, in a cultivated field, 1,900 feet east and 2,000 feet south of northwest corner of sec 25, T. 12 S., R. 21 E., 1.5 miles south of Linwood, Leavenworth County:

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) dry; weak, fine, granular structure; common fine roots; slight effervescence; mildly alkaline; abrupt, smooth boundary.

C—9 to 60 inches, light brownish-gray (10YR 6/2) fine sand, light gray (10YR 7/2) dry; single grained; slight effervescence; neutral.

The sandy material is typically more than 60 inches thick, but in places silty material is below a depth of 35 inches. The Ap or A1 horizon ranges from 6 to less than 10 inches. It is dark grayish-brown or very dark grayish-brown loamy fine sand, fine sandy loam, or fine sand. In places the C horizon is grayish brown and has yellowish-brown mottles. It is fine sand or loamy fine sand.

Sarpy soils are associated with Eudora and Haynie soils. They contain more sand throughout than Eudora and Haynie soils and lack the thicker, dark-colored A1 horizon that is typical of Eudora soils.

Sarpy-Haynie complex (0 to 3 percent slopes) (Sa).—This mapping unit is about 55 percent Sarpy soil, 35 percent Haynie soil, and 10 percent a soil that is similar to the Haynie soil but has sandy alluvium at a depth of about 30 inches. The Sarpy and Haynie soils

formed in sandy and loamy alluvium. They are mainly on narrow, long, hummocky ridges adjacent to the rivers, typically inside the river bends. Some are in narrow, slightly higher areas on the bottom land, away from the river.

In places the Sarpy soil is underlain by medium-textured alluvium below a depth of 20 inches. The Haynie soil has a profile similar to that described as representative of the series, but the surface layer contains more fine and medium sand in many places. Included in mapping are areas of Eudora and Onawa soils.

A small acreage is cleared of timber and cultivated. The Sarpy soil is low in organic-matter content and fertility. If improved by growing green-manure crops and legumes, it can be used for vegetables and watermelons.

The soils in this unit are droughty, but irrigation water is available. Sprinklers are used for irrigation. Crops respond very well to fertilization. Soil blowing is a serious hazard, but it can be controlled by minimum tillage and stubble mulching and by growing green-manure crops. The soils are subject to occasional flooding. Capability unit IIIw-2; woodland suitability group 4s2.

Sharpsburg Series

The Sharpsburg series consists of deep, gently sloping to sloping, moderately well drained soils on uplands. These soils formed in loess.

In a representative profile the surface layer is silty clay loam about 15 inches thick. It is very dark grayish brown in the upper part and dark brown and very dark grayish brown in the lower part. The subsoil is about 27 inches of firm silty clay loam. It is dark brown in the upper part, brown mottled with yellowish brown and grayish brown in the middle part, and yellowish brown mottled with grayish brown and strong brown in the lower part. The underlying material is yellowish-brown silty clay loam.

Sharpsburg soils have high natural fertility and high available water capacity. Permeability is moderately slow. The soils are friable and easily tilled. If limed, they are medium acid to neutral in the surface layer. The subsoil is strongly acid to slightly acid. Lime is beneficial to most crops, especially legumes. Crops also respond well to fertilization.

Most of the acreage is cultivated, and the main crops are corn, grain sorghum, soybeans, and wheat. The soils are well suited to hay, tame pasture, and orchards. The native vegetation is tall grasses.

Representative profile of Sharpsburg silty clay loam, 1 to 4 percent slopes, in a cultivated field, 1,200 feet north and 150 feet east of the southwest corner of sec. 28, T. 10 S., R. 22 E., about one-half mile north of Piper, Wyandotte County:

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; friable, hard; plentiful fine roots; common worm casts; neutral; abrupt, smooth boundary.

A12—8 to 11 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard;

- plentiful fine roots; few worm casts; slightly acid; clear, smooth boundary.
- A3—11 to 15 inches, dark-brown (10YR 4/3) and very dark grayish-brown (10YR 3/2) silty clay loam, dark brown (10YR 3/3) crushed; moderate, very fine and fine, subangular blocky structure; friable, hard; plentiful fine roots; few worm casts; slightly acid; clear, smooth boundary.
- B21t—15 to 21 inches, dark-brown (10YR 4/3), heavy silty clay loam, brown (10YR 4/3) crushed, brown (10YR 5/3) dry; very dark grayish-brown (10YR 3/2) coatings on peds; few, fine, faint, yellowish-brown (10YR 5/6) mottles; moderate, fine and medium, subangular blocky structure; firm, hard; few fine roots; medium acid; weak, patchy, clay films; clear, smooth boundary.
- B22t—21 to 30 inches, brown (10YR 4/3) heavy silty clay loam, pale brown (10YR 6/3) dry; dark grayish-brown (10YR 4/2) coatings on peds; common, fine, distinct, yellowish-brown (10YR 5/6) and grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; firm, hard; few fine roots; common, round, black concretions; many open pores; weak, continuous, clay films; medium acid; gradual, smooth boundary.
- B3t—30 to 42 inches, yellowish-brown (10YR 5/4) silty clay loam, light yellowish brown (10YR 6/4) dry; fine and medium, distinct mottles of strong brown (7.5YR 5/6) and grayish brown (10YR 5/2); weak, coarse, blocky parting to weak, medium, subangular blocky structure; firm, hard; common, soft, black spots; many open pores; medium acid; gradual, smooth boundary.
- C—42 to 60 inches, yellowish-brown (10YR 5/4) light silty clay loam, light yellowish brown (10YR 6/4) dry; common, fine, distinct, grayish-brown (10YR 5/2) and strong-brown (7.5YR 5/6) mottles; weak, coarse, prismatic structure; friable, hard; fine roots; common, soft, black spots; many open pores; slightly acid.

The solum ranges from 42 to 60 inches in thickness. The A horizon generally is very dark brown or very dark grayish brown silty clay loam, but it is silt loam in places. The B horizon generally is heavy silty clay loam, but it is light silty clay in places.

Sharpsburg soils are associated with Elmont, Grundy, Gymer, Ladoga, Marshall, Oska, Pawnee, and Shelby soils. They have less clay in the B2t horizon than Grundy soils and are not so brown as Gymer and Oska soils. They contain less sand and gravel than Pawnee and Shelby soils, which formed in glacial till. They have a thicker, dark-colored A horizon than Ladoga soil and have more clay in the B2 horizon than Elmont and Marshall soils.

Sharpsburg silty clay loam, 1 to 4 percent slopes (Sb).—This soil is on ridgetops. It has the profile described as representative of the series. Included in mapping are small areas of Grundy, Gymer, Pawnee, and Shelby soils.

This soil is best suited to corn, soybeans, and grain sorghum. Erosion is a hazard, but it can be controlled by contour farming, minimum tillage, or stubble mulching, or by a combination of those practices. Capability unit IIe-1; not assigned to a woodland suitability group.

Sharpsburg silty clay loam, 4 to 8 percent slopes (Sc).—This soil has convex to concave slopes. It has a profile similar to that described as representative of the series, but the surface layer is about 5 inches thinner and the subsoil contains less clay.

Included with this soil in mapping are small areas of Grundy, Oska, Pawnee, and Shelby soils. Also included are small areas of eroded Sharpsburg soils.

This soil is suited to corn, grain sorghum, soybeans, hay, and small grain. Some areas are used for tame pasture. Erosion is a serious hazard, but it can be controlled by terraces, contour farming, minimum

tillage, or stubble mulching, or by a combination of those practices. Fertility and tilth can be maintained by growing green manure crops and legumes and applying farm manure. Tame pasture can be kept vigorous under additions of fertilizer and lime and good grazing management. Capability unit IIIe-1; not assigned to a woodland suitability group.

Shelby Series

The Shelby series consists of deep, gently sloping to strongly sloping, moderately well drained soils on uplands. These soils formed in glacial till.

In a representative profile the surface layer is about 13 inches thick. It is very dark brown loam in the upper part and very dark grayish-brown clay loam in the lower part. The subsoil is about 27 inches of dark yellowish-brown, firm clay loam that has yellowish-red, strong-brown and yellowish-brown mottles in the lower part. The underlying material is light olive-brown and light yellowish-brown clay loam that has lime concretions in the lower part.

Shelby soils have high available water capacity and moderately slow permeability. If limed, the surface layer is medium acid to neutral. The subsoil is strongly acid to slightly acid. Lime is beneficial to most crops, especially legumes. Crops also respond well to fertilization.

The native vegetation is tall grasses. Most of the gently sloping and sloping soils are cultivated, and the main crops are grain sorghum, corn, soybeans, and wheat. The strongly sloping soils are best suited to hay or tame pasture. Shelby soils are also suited to orchards.

Representative profile of Shelby loam, 4 to 8 percent slopes, in a cultivated field, 2,400 feet east and 150 feet north of southwest corner of sec. 10, T. 12 S., R. 22 E., Leavenworth County:

- Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard; plentiful fine roots; common worm casts; few pebbles; neutral; abrupt, smooth boundary.
- A3—7 to 13 inches, very dark grayish-brown (10YR 3/2) light clay loam, dark brown (10YR 3/3) crushed, brown (10YR 5/3) dry; common dark-brown (10YR 4/3) worm casts; moderate, fine and very fine, subangular blocky structure; friable, hard; plentiful fine roots; common pebbles; slightly acid; clear, smooth boundary.
- B21t—13 to 21 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) clay loam, dark yellowish brown (10YR 4/4) crushed, yellowish brown (10YR 5/4) dry; dark-brown (10YR 3/3) coatings on peds; moderate, fine, subangular blocky structure; firm, hard; plentiful fine roots; weak, continuous, clay films; many pebbles; medium acid; clear, smooth boundary.
- B22t—21 to 28 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) clay loam; few, fine, faint, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/6) mottles; moderate, fine and medium, subangular blocky structure; firm, hard; few fine roots; common sand grains and fine pebbles; weak, continuous, clay films; medium acid; gradual, smooth boundary.
- B3—28 to 40 inches, dark yellowish-brown (10YR 4/4) clay loam, yellowish brown (10YR 5/4) dry; many, fine and medium, distinct, yellowish-brown (10YR 5/6), strong-brown (7.5YR 5/6) and grayish-brown (10YR 5/2) mottles; weak, coarse, blocky structure; firm, hard;

few fine roots; many sand grains and fine pebbles; many open pores; slightly acid; diffuse, smooth boundary.

C1—40 to 54 inches, light olive-brown (2.5Y 5/4) clay loam, light yellowish brown (2.5Y 6/4) dry; many, fine and medium, prominent mottles of yellowish brown (10YR 5/6) and few, fine, distinct mottles of grayish brown (10YR 5/2); massive; friable, hard; many sand grains and fine pebbles; neutral; clear, smooth boundary.

C2—54 to 75 inches, light yellowish-brown (2.5Y 6/4) and light olive-brown (2.5Y 5/4) clay loam; common, fine and medium, distinct strong-brown (7.5YR 5/6), yellowish-brown (10YR 5/6), and grayish-brown (2.5Y 5/2) mottles; massive; friable, hard; many sand grains and fine pebbles; few lime concretions; strong effervescence; moderately alkaline.

The solum ranges from 35 to 55 inches in thickness. The A horizon is generally very dark brown or very dark grayish-brown loam, but in places it is light clay loam. The C horizon is generally clay loam, but in places it is heavy clay loam or light clay below a depth of 30 to 40 inches. Segregated calcium carbonate is common below a depth of 50 inches.

Shelby soils are associated with Armster, Grundy, Pawnee, and Sharpsburg soils. They have more glacial sand and less clay in the B horizon than Grundy and Sharpsburg soils. They have less clay in the B2t horizon than Pawnee soils. They have less clay in the B2t horizon than Armster soils and, unlike those soils, lack an A2 horizon.

Shelby loam, 1 to 4 percent slopes (Se).—This soil is on ridgetops. It has a profile similar to that described as representative of the series, but in many places the surface layer is more silty because it is covered with a thin mantle of loess. A layer of heavy clay loam or light clay generally is at a depth of 30 to 40 inches. Included in mapping are small areas of Pawnee and Sharpsburg soils.

These soils are best suited to corn, soybeans, small grain, and grain sorghum. Runoff and erosion are serious hazards, but they can be controlled by contour farming, stubble mulching, or minimum tillage, or by a combination of those practices. Fertility and tilth can be maintained by growing legumes and green manure crops. Capability unit IIe-1; not assigned to a woodland suitability group.

Shelby loam, 4 to 8 percent slopes (Sh).—This soil is on the convex to concave sides and at the narrow ends of ridges. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Elmont, Oska, Pawnee, and Sharpsburg soils. Also included are spots of eroded Shelby soils and of a soil that is similar to Shelby soils but has a browner subsoil.

This soil is suited to corn, soybeans, grain sorghum, and small grain. In places it is used for hay and tame pasture. Erosion is a serious hazard, but it can be controlled by terraces, contour farming, stubble mulching, or minimum tillage, or by a combination of those practices. Fertility, tilth, and organic-matter content can be maintained by growing green manure crops and legumes and applying farm manure. Tame grass pasture can be kept vigorous under adequate fertilization and good grazing management. Wildlife habitat can be developed. Capability unit IIIe-1; not assigned to a woodland suitability group.

Shelby loam, 8 to 12 percent slopes (Sm).—This soil has convex to concave slopes. It is below areas of Grundy and Pawnee soils. It has a profile similar to

that described as representative of the series, but the surface layer is thinner and the subsoil has less clay.

Included with this soil in mapping are small areas of Elmont and Pawnee soils. Also included are spots of eroded Shelby soils and a soil that is similar to Shelby soils but has a browner subsoil.

This soil is best suited to hay and tame pasture. It is suited to small grain and occasionally to grain sorghum or another row crop. Erosion is a serious hazard in cultivated areas, but it can be controlled by terraces, contour farming, stubble mulching, or minimum tillage, or by a combination of those practices. Fertility and tilth can be maintained by growing green manure crops and legumes and applying farm manure. Tame grass hay and tame grass pasture respond well to fertilization. Tame pasture remains vigorous under good grazing management. Wildlife habitat can be developed. Capability unit IVE-1; not assigned to woodland suitability group.

Shelby-Pawnee complex, 4 to 8 percent slopes (Sp).—This mapping unit is about 60 percent Shelby loam and 40 percent Pawnee clay loam. These soils are on the convex and concave sides and the narrow tops of ridges. The Shelby soil has a profile similar to that described as representative of the series, but it generally has more clay below a depth of 30 to 40 inches. The Pawnee soil has a profile similar to that described as representative of the series, but in places the surface layer is loam.

Included with this complex in mapping are small areas of Elmont, Grundy, and Sharpsburg soils and spots of eroded Pawnee and Shelby soils. Wet and seepy spots are common at the contact between the loess and clayey glacial till.

This mapping unit is suited to corn, soybeans, grain sorghum, and small grain. Alfalfa and tame grasses grow well on these soils. Crops respond well to fertilizer and lime. Erosion can be controlled by terraces, contour farming, stubble mulching, and minimum tillage, or by a combination of those practices. Fertility and tilth can be maintained by growing green manure crops and legumes and applying farm manure. Wildlife habitat for upland game can be developed. Wet and seepy areas can be tile drained. Tame grass pasture can be maintained in a vigorous condition if fertilized and limed and grazing is well managed. Capability unit IIIe-1; not assigned to a woodland suitability group.

Shelby-Pawnee complex, 4 to 8 percent slopes, eroded (Ss).—This mapping unit has about the same percentage of Shelby and Pawnee soils as Shelby-Pawnee complex, 4 to 8 percent slopes. These soils are at the heads of drainageways. They have convex slopes. In most areas the surface layer is mixed with the subsoil and contains more clay than that in the profile described as representative of the Shelby and the Pawnee series. In most places, it is clay loam.

Included with this complex in mapping are small areas of Elmont and Grundy soils. Wet and seepy spots are at the contact between the loess and clayey glacial till.

This mapping unit is best suited to hay or tame pasture. If cultivated, erosion can be controlled and runoff reduced by terraces, contour farming, stubble mulching, and minimum tillage, or by a combination

of those practices. Organic-matter content can be increased and fertility and tilth maintained by growing legumes and green manure crops and applying farm manure. Wet spots can be tile drained. Tame grass pasture can be kept vigorous if fertilized and limed and grazing is well managed. Wildlife habitat can be developed. Capability unit IVE-4; not assigned to a woodland suitability group.

Sibleyville Series

The Sibleyville series consists of friable, moderately deep, sloping, well-drained soils on uplands. These soils formed in residuum from sandstone interbedded with shale.

In a representative profile the surface layer is 13 inches of very dark grayish-brown loam. The subsoil is about 15 inches thick. The upper part is 7 inches of very dark grayish-brown and yellowish-brown, friable clay loam, and the lower part is about 8 inches of yellowish-brown, firm clay loam mottled with strong brown. The underlying material is about 4 inches of yellowish-brown loam. Micaceous sandstone is at a depth of 32 inches.

Sibleyville soils have medium fertility, low to moderate available water capacity, and moderate permeability. They are friable and easily tilled.

These soils are used mainly for tame pasture. If cultivated, they are best suited to grain sorghum and small grain. They are well suited to strawberries and truck crops.

Representative profile of Sibleyville loam, 4 to 8 percent slopes, in a cultivated field, 200 feet east and 500 feet south of northwest corner of sec. 17, T. 12 S., R. 21 E., Leavenworth County:

- Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak, fine, subangular blocky structure; friable, slightly hard; few fine roots; few worm casts; neutral; abrupt, smooth boundary.
- A12—8 to 13 inches, very dark grayish-brown (10YR 3/2) heavy loam, dark grayish brown (10YR 4/2) dry; moderate, fine, granular structure; friable, slightly hard; few fine roots; few worm casts and channels; neutral; gradual, smooth boundary.
- B21t—13 to 20 inches, very dark grayish-brown (10YR 3/2) and yellowish-brown (10YR 5/4 and 5/6) clay loam; weak, fine, subangular blocky structure; friable, hard; few roots; few weathered sandstone fragments; slightly acid; clear, smooth boundary.
- B22t—20 to 28 inches, yellowish-brown (10YR 5/6 and 5/4) clay loam; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; firm, hard; few roots; few sandstone fragments; few soft black spots; medium acid; clear, smooth boundary.
- C—28 to 32 inches, yellowish-brown (10YR 5/4 and 5/6) loam, massive; friable, hard; few fine roots; neutral; clear, smooth boundary.
- R—32 inches, micaceous sandstone.

Depth to sandstone ranges from 20 to 40 inches. The A horizon is very fine sandy loam in places. The B horizon is brown or yellowish-brown heavy loam or clay loam. The solum is medium acid to neutral.

Sibleyville soils are associated with Elmont and Vinland soils. They contain more sand throughout and are more shallow than Elmont soils. They are deeper over sandstone than Vinland soils and have more clay in the B horizon.

Sibleyville loam, 4 to 8 percent slopes (Sy).—This soil has concave slopes. Included in mapping are small areas of Elmont, Shelby, and Vinland soils.

Fertility and organic-matter content can be increased by applying farm manure and growing green manure crops, both of which are especially beneficial to strawberries and other garden crops. Crops respond well to fertilizer. Small areas of this soil can be irrigated from wells or ponds. In cultivated areas, erosion can be controlled by contour farming, minimum tillage, and stubble mulching, or by a combination of those practices.

Good grazing management is needed to keep tame and native pasture vigorous. Tame pasture responds well to fertilization and lime. Wildlife habitat for upland game can be developed. Capability unit IVE-6; not assigned to a woodland suitability group.

Sogn Series

The Sogn series consists of shallow, strongly sloping, somewhat excessively drained soils on uplands. These soils formed in material weathered from limestone.

In a representative profile the surface layer is about 6 inches of very dark brown silty clay loam. The next layer is about 10 inches of very dark grayish-brown, firm, flaggy silty clay loam. It is underlain by limestone.

Sogn soils have very low available water capacity, medium natural fertility, and moderate permeability. In many areas the limestone is fractured, and roots can grow in the cracks.

These soils are suited to woodland. Some areas are cleared of timber and planted to tame grass.

Representative profile of Sogn silty clay loam in an area of Gosport-Sogn complex in timber, 450 feet west and 1,400 feet north of southeast corner of sec. 15, T. 12 S., R. 22 E., Leavenworth County:

- A1—0 to 6 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; strong, very fine and fine, subangular blocky structure; firm, hard; plentiful fine and medium roots; few worm casts; few limestone fragments; moderately alkaline; clear, smooth boundary.
- AC—6 to 16 inches, very dark grayish-brown (10YR 3/2) flaggy silty clay loam, dark grayish brown (10YR 4/2) dry; matrix, moderate, fine and medium, subangular blocky structure; few medium and coarse roots; firm, hard; few limestone fragments; moderately alkaline; abrupt, smooth boundary.
- R—16 inches, limestone.

Depth to limestone is less than 20 inches. In places the A horizon is silt loam. It is black to dark brown. In places there is no flaggy silty clay loam horizon, and the A horizon is underlain directly by solid limestone. These soils are slightly acid to moderately alkaline.

Sogn soils are associated with Gosport, Martin, and Oska soils. They formed in material weathered from limestone, whereas, Gosport and Martin soils formed in material drained from shale. They are shallower than Oska soils and are not so brown as those soils.

Vinland Series

The Vinland series consists of shallow, sloping to strongly sloping, somewhat excessively drained soils on uplands. These soils formed in material weathered from sandstone interbedded with shale.

In a representative profile the surface layer is about 11 inches of very dark grayish-brown loam. The subsoil is about 7 inches of yellowish-brown, friable

loam. The underlying material is yellowish-brown sandstone.

Vinland soils have low available water capacity and moderate permeability. They are medium acid or slightly acid in the surface layer and subsoil. Lime is beneficial to tame grasses. Tame grasses also respond well to fertilization.

These soils are best suited to native pasture or tame pasture. They are not suited to cultivated crops. Native grasses are big bluestem, little bluestem, switchgrass, and indiangrass.

Representative profile of Vinland loam in an area of Vinland-Sibleyville complex, 5 to 12 percent slopes, in native pasture, 1,400 feet west and 1,000 feet north of southeast corner of sec. 2, T. 11 S., R. 21 E., Leavenworth County:

A1—0 to 11 inches, very dark grayish-brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; friable, slightly hard; abundant fine and medium roots; common worm casts; slightly acid; gradual, smooth boundary.

B2—11 to 18 inches, yellowish brown (10YR 5/4) loam, light yellowish brown (10YR 6/4) dry, brown (10YR 4/3) crushed; weak, fine and medium, subangular blocky structure; friable, slightly hard; plentiful fine roots; common worm casts; medium acid; clear, smooth boundary.

C—18 to 25 inches, yellowish-brown (10YR 5/4 and 5/6) weathered sandstone.

Depth to weathered bedrock is less than 20 inches. The A horizon is very dark brown or very dark grayish-brown loam or fine sandy loam, but in places it is silt loam. The B horizon is brown or yellowish brown. It is fine sandy loam or silt loam in places. The C horizon is medium acid or strongly acid weathered sandstone interbedded with shale.

Vinland soils are associated with Basehor, Elmont, and Sibleyville soils. They have a thicker, dark-colored surface layer than Basehor soils. They are shallower than Elmont and Sibleyville soils and have less clay in the B2 horizon.

Vinland-Sibleyville complex, 5 to 12 percent slopes (Vs).—This mapping unit is about 45 percent Vinland loam and 40 percent Sibleyville loam. These soils have a profile similar to that described as representative of their series. The Vinland soil is on the irregularly shaped convex sides and the tops of ridges, and the Sibleyville soil is on the irregularly shaped concave sides of ridges.

Included with this unit in mapping are areas of Elmont silt loam and small areas of Martin, Pawnee, and Shelby soils. The included soils make up about 15 percent of the mapping unit. In places are outcrops of sandstone, areas of eroded Vinland and Sibleyville soils, and slickspots.

Most of the acreage is used for native pasture or tame pasture. A few small areas of Sibleyville loam can be used for special crops, such as strawberries and other berries. Good management of native pasture and tame pasture is needed, including proper stocking rates and brush control. Tame pasture responds well to fertilization. Capability unit VIe-2; not assigned to a woodland suitability group.

Wabash Series

The Wabash series consists of deep, nearly level, very poorly drained clayey soils on the bottom land of Stranger Creek. These soils formed in fine-textured alluvium.

In a representative profile the surface layer is

about 19 inches of black silty clay (fig. 14). The subsoil is about 41 inches of very firm silty clay. It is very dark gray in the upper part and dark gray in the lower part.

Wabash soils have high natural fertility, moderate available water capacity, and very slow permeability.

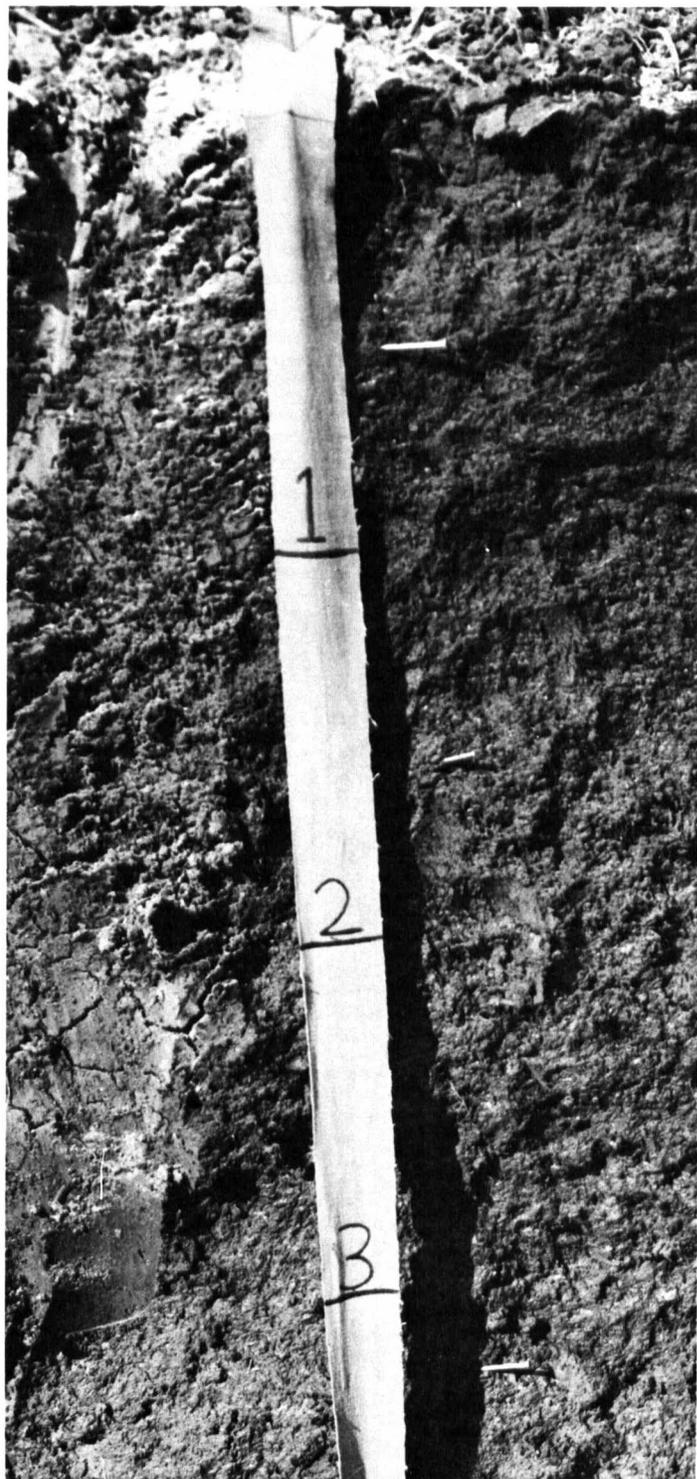


Figure 14.—Profile of Wabash silty clay.

They have slow runoff and dry slowly after rain. They are subject to frequent flooding.

These soils generally are cultivated and are best suited to grain sorghum and soybeans. Corn and small grain can be grown occasionally. Small areas are still wooded. Tame pasture is well suited and responds well to fertilization. Alfalfa will not survive in most years because the soil is wet and flooded. The native vegetation is tall prairie grass.

Representative profile of Wabash silty clay in tame pasture, 1,300 feet east and 2,200 feet south of center of sec. 17, T. 9 S., R. 21 E., Leavenworth County:

Ap—0 to 6 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; weak, fine, subangular blocky structure; firm, hard; plentiful medium and fine roots; few worm casts; neutral; clear, smooth boundary.

A1—6 to 19 inches, black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; moderate, fine, subangular blocky structure; very firm, very hard; few fine roots; neutral; diffuse, smooth boundary.

B1g—19 to 41 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) dry; moderate, fine, subangular blocky structure; very firm, very hard; few fine roots; neutral; diffuse, smooth boundary.

B2g—41 to 60 inches, dark-gray (10YR 4/1) silty clay, gray (10YR 6/1) dry; few, fine, faint, grayish-brown (2.5Y 5/2) mottles; weak, fine, subangular blocky structure; common very fine lime concretions; mildly alkaline.

The solum ranges from 40 to more than 60 inches in thickness. The A horizon is neutral or slightly acid, and the B horizon is neutral or mildly alkaline. In places the A horizon is silty clay loam. Mottles are above a depth of 20 inches in places. In most places lime concretions are below a depth of 40 inches.

Wabash soils are associated with Bremer, Kennebec, Onawa, and Zook soils. They contain more clay than Bremer, Kennebec, and Zook soils and are not so well drained. They are clayey throughout, while Onawa soils are underlain by loamy material at a depth of less than 40 inches.

Wabash silty clay (0 to 1 percent slopes) (Wa).—This soil is in slightly depressed backwater areas adjacent to uplands. Included in mapping are small areas of Kennebec, Martin, and Zook soils. Also included are wet spots, many of which hold water for long periods.

This soil is suited to most cultivated crops and tame pasture. It is also suited to trees, such as cottonwoods. Wetness is the main limitation.

This soil is not easy to work. It is sticky and plastic if tilled when wet and very hard if tilled when dry. Drainage, by bedding and ditches, for example, is needed in cultivated areas. Capability unit IIIw-1; woodland suitability group 5w3.

Welda Series

The Welda series consists of deep, sloping to moderately steep, well-drained soils on uplands. These soils are along the Kansas River. They formed in loess.

In a representative profile the surface layer is about 6 inches of very dark grayish-brown silt loam. The subsurface layer is about 6 inches of brown silt loam. The subsoil is about 36 inches of friable and firm silty clay loam. It is dark brown in the upper 4 inches and reddish brown in the lower 32 inches. The underlying material is brown silty clay loam.

Welda soils have medium fertility, high available water capacity, and moderately slow permeability. They are low in organic-matter content. The surface layer is medium acid to neutral, and the subsoil is

strongly acid to slightly acid. Lime is beneficial to most crops, especially legumes. Crops respond well to fertilization.

The native vegetation is timber, chiefly oak and hickory. Many areas are cleared and are cultivated or used for tame pasture. Wheat and grain sorghum are the main crops. The soils are also suited to orchards.

Representative profile of Welda silt loam, 4 to 9 percent slopes, in timber, 700 feet west and 200 feet north of center of sec. 18, T. 12 S., R. 22 E., about 2 miles east of Linwood, Leavenworth County:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, granular structure; very friable, soft; plentiful fine and medium roots; common worm casts; few worm channels; neutral; clear, smooth boundary.

A2—6 to 12 inches, brown (7.5YR 4/2) silt loam, pinkish gray (7.5YR 6/2) dry; weak, fine, granular structure; very friable, slightly hard; few fine roots; few worm casts; slightly acid; clear, smooth boundary.

B1—12 to 16 inches, dark-brown (7.5YR 4/4) light silty clay loam, brown (7.5YR 5/4) dry; weak, fine, subangular blocky structure; friable, hard; light-gray (10YR 7/2) silt coats on surfaces of pedis; few fine roots; few worm channels; medium acid; clear, smooth boundary.

B2t—16 to 28 inches, reddish brown (5YR 4/4) heavy silty clay loam, reddish brown (5YR 5/4) dry; moderate, fine and medium, subangular blocky structure; firm, hard; few fine roots; silt particles and thin clay films on surfaces of pedis; medium acid; gradual, smooth boundary.

B22t—28 to 37 inches, reddish-brown (5YR 4/4) silty clay loam, yellowish red (5YR 5/6) dry; weak, medium, subangular blocky structure; firm, hard; few fine and medium roots; thin clay films on surfaces of pedis; porous; medium acid; gradual, smooth boundary.

B3—37 to 48 inches, reddish-brown (5YR 5/4) silty clay loam, reddish yellow (5YR 6/6) dry; weak, coarse, blocky structure; firm; hard; few fine roots; medium acid; diffuse, smooth boundary.

C—48 to 70 inches, brown (7.5YR 5/4) light silty clay loam, pink (7.5YR 7/4) dry; few, faint, fine, grayish-brown (10YR 5/2) mottles; weak, coarse, prismatic structure; friable, slightly hard; many open pores; strongly acid.

The solum ranges from 40 to more than 60 inches in thickness. The A1 horizon is 6 inches or less thick. It is very dark brown or very dark grayish brown. The Ap horizon is dark grayish-brown silt loam, but it is silty clay loam in places. The B2t horizon is generally reddish brown or yellowish red. In places the matrix is dark grayish brown or brown and has many reddish-brown or yellowish-red mottles.

Welda soils are associated with Armster, Gymer, Konawa, and Ladoga soils. They do not contain the sand and glacial pebbles that are typical of Armster soils, and they have more silt in the B2t horizon than Konawa soils. They have a thinner A1 horizon than Gymer soils and, unlike those soils, have an A2 horizon. Unlike Ladoga soils, they lack the hues of 10YR in the B2t horizons.

Welda silt loam, 4 to 9 percent slopes (Wc).—This soil is on the convex to concave sides and the tops of ridges. It has the profile described as representative of the series. Included in mapping are small areas of Konawa, Gymer, and Ladoga soils.

This soil is best suited to small grain and grain sorghum. Erosion is a serious hazard, but it can be controlled by terraces, contour farming, stubble mulching, and minimum tillage, or by a combination of those practices. Fertility can be maintained and the content of organic matter increased by growing green manure crops and legumes and by applying

farm manure. Stands of native timber can be improved by thinning and other management. Capability unit IIIe-3; woodland suitability group 4o1.

Welda silt loam, 9 to 15 percent slopes (Wd).—This soil has convex to concave slopes. It has a profile similar to that described as representative of the series, but the subsoil is thinner and has less clay. Included in mapping are small areas of Armster and Konawa soils.

Much of the acreage is in native timber. Some areas are cleared and used for tame pasture and cultivated crops. In cultivated areas, erosion is a serious hazard, but it can be controlled by contour farming, stubble mulching, and minimum tillage, or by a combination of those practices. Tame pasture can be kept vigorous if fertilized and limed and good grazing is well managed. Stands of native timber can be improved by stand reduction and selective cutting. Capability unit IVe-3; woodland suitability group 4o1.

Zook Series

The Zook series consists of deep, nearly level, poorly drained soils on the bottom land of Stranger Creek. These soils formed in moderately fine textured alluvium.

In a representative profile the surface layer is about 41 inches of silty clay loam. It is black in the upper part and very dark gray in the lower part. The subsoil is about 11 inches of mottled dark gray and very dark gray, firm silty clay. The underlying material is mottled gray and grayish-brown silty clay loam.

Zook soils have high available water capacity, slow permeability, and high natural fertility. Crops, especially tame grasses, respond well to fertilization. These soils are neutral to slightly acid throughout. Flooding is frequent.

Most of the acreage is cultivated. The soils are well suited to corn, sorghum, soybeans, and small grain. They are also suited to hay and tame grasses. The native vegetation is tall prairie grass.

Representative profile of Zook silty clay loam in a cultivated field, 2,000 feet south and 400 feet east of the northwest corner of sec. 28, T. 9 S., R. 21 E., Leavenworth County:

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak, granular structure; friable, hard; plentiful fine roots; few worm casts; neutral; abrupt, smooth boundary.

A12—7 to 22 inches, black (10YR 2/1) heavy silty clay loam, dark gray (10YR 4/1) dry; common, fine, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, blocky parting to weak, fine, subangular blocky structure; firm, hard; few fine roots; few worm casts; gray (10YR 5/1) dry coatings on ped surfaces; neutral; gradual, smooth boundary.

A13—22 to 41 inches, very dark gray (10YR 3/1) heavy silty clay loam, dark gray (10YR 4/1) dry; common, fine, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, blocky parting to weak, fine, subangular blocky structure; firm, hard; few fine roots; silt coatings on ped surfaces; neutral; gradual, smooth boundary.

Bg—41 to 52 inches, dark-gray (10YR 4/1) and very dark-gray (10YR 3/1) light silty clay; many, fine, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, blocky parting to weak, fine

and medium, subangular blocky structure; firm, hard; gray (10YR 6/1) dry silt coatings on ped surfaces; neutral; gradual, smooth boundary.

Cg—52 to 76 inches, gray (10YR 6/1) and grayish-brown (2.5Y 5/2) silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, coarse, blocky structure; firm, hard; neutral.

The solum ranges from 36 to 60 inches or more in thickness. The A horizon ranges from 24 to 48 inches in thickness and in places is silt loam in the upper part. The B horizon is heavy silty clay loam in places. Gray silt coatings on the ped surfaces are common in many places.

Zook soils are associated with Bremer, Kennebec, and Wabash soils. They are more uniformly textured throughout than Bremer soils. They contain more clay throughout than Kennebec soils and less clay throughout than Wabash soils.

Zook silty clay loam (0 to 1 percent slopes) (Zo).—This soil is on bottom land adjacent to the natural levee of Stranger Creek. Included in mapping are small areas of Kennebec and Wabash soils.

This soil is suited to all crops grown in the county. It is frequently flooded. Wetness can be a limitation in some years. Bedding and ditches are examples of the drainage practices needed. Capability unit IIw-2; woodland suitability group 4w2.

Use and Management of the Soils

The soils in Leavenworth County and in the western part of Wyandotte County are used mainly for cultivated crops and pasture. This section explains the capability classification used by the Soil Conservation Service, tells what crops can be grown on the soils in the counties, and lists predicted yields of nonirrigated crops under high level management. It suggests management of the soils for woodland and wildlife. This section also defines the limitations of the soils to be considered in engineering and in town and country planning.

Almost all mapping units have small areas of contrasting soils or special features, such as rock outcrop, that affect use and management. These areas are identified by spot symbols on the soil map. The spot symbols used on the soil map of Leavenworth and Wyandotte Counties are shown at the back of the survey under "Conventional Signs."

The symbol for a severely eroded spot represents an area of 3 acres or less. Crop growth is poor in these areas because fertility is low and tilth is poor. Tilling or preparing a good seedbed in the clayey material exposed by erosion is difficult.

The symbol for rock outcrop represents an area of 2 acres or less. It is used in areas of moderately deep or deep soils that do not ordinarily have outcrops of bedrock. Rock outcrop interferes with tillage, planting, and harvesting. It also significantly affects construction of terraces and waterways.

The symbol for a saline spot represents an area of 2 to 5 acres. These areas are high in soluble salts, which significantly affect the growth of crops. The soluble salts are mainly chlorides and sulfates of calcium, magnesium, and sodium but can include smaller amounts of bicarbonates and carbonates of the same elements. The salts named apply to both saline and alkali soils.

The symbol for a sand spot represents an area of 2 acres or less. It is used where small spots of sand or loamy sand occur on the surface of soils that ordinarily have a loam or a more clayey surface layer. Sand spots are subject to blowing or drought.

The symbol for a wet spot represents an area of 2 to 5 acres. It is used where the soils are wet during a part of the growing season. Wetness reduces the yield of most crops in years of above average rainfall. In some years it curtails harvesting or planting.

Crops and Pasture³

A large acreage of the nearly level to sloping soils is in crops or tame pasture. The loamy and silty soils are suited to corn, grain and forage sorghum, soybeans, alfalfa, and small grain. Corn does not grow so well on soils that have a clayey subsoil. The tame grasses commonly grown are bromegrass, fescue, and reed canarygrass. The legumes commonly grown are alfalfa, red clover, and lespedeza.

The loamy soils on the river bottoms are well suited to vegetables because adequate water for irrigation is available. Part of the survey area is now used for vegetables, and the potential for expanded production is good, if the labor supply is adequate. Small orchards are common, but again, the main reason for slow expansion is dependence on an adequate labor supply.

Most of the soils have high natural fertility, but crops and tame grasses respond well to nitrogen and phosphorus. Some soils are low in potassium. Lime is beneficial to all crops, especially legumes, on all upland soils. The organic-matter content is low, but can be increased by applying farm manure and growing legumes and green manure crops. In general, it is important to maintain tilth and the level of fertility in all the soils.

Erosion is a serious hazard on the sloping soils. Terraces, contour farming, minimum tillage, and stubble mulching, or a combination of those practices are needed to control erosion and reduce runoff. Soil blowing is a hazard in spring on Eudora, Haynie, and Sarpy soils, but it can be controlled by minimum tillage and stubble mulching.

Tame grass pasture can be kept vigorous under controlled and deferred grazing, brush control, and adequate fertilization. Native pasture responds to the same management, but no fertilization is necessary.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible, but unlikely, major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels—the capability class, the subclass, and the unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In Class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater limitations. In Class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. In Leavenworth and Wyandotte Counties there are no Class VIII soils.

Capability subclasses are soils grouped 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, but not in Leavenworth and Wyandotte Counties, 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 or range, woodland, wildlife, 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-1 or IIIw-2. 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.

Capability unit numbers generally are assigned locally, but they are a part of a statewide system. The capability classes, subclasses, and units in the capability system in Leavenworth and Wyandotte Counties are described in the list that follows. Suggestions for use and management of the soils are given in the section Descriptions of the Soils. The unit designation is given in the Guide to Mapping Units. For a complete explanation of the capability classification, see Agriculture Handbook No. 210, *Land Capability Classification* (13).

Class I. Soils have few limitations that restrict their use.

Unit I-1. Deep, nearly level, well-drained silt loams on low terraces.

³ EARL J. BONDY, conservation agronomist, Soil Conservation Service, Salina, Kansas, helped prepare this section.

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

Subclass IIe. Soils subject to moderate erosion unless protected.

Unit IIe-1. Deep, gently sloping, moderately well drained and well drained loams, silt loams, and silty clay loams on uplands.

Unit IIe-2. Deep, gently sloping, moderately well drained and somewhat poorly drained clay loams and silty clay loams on uplands.

Subclass IIw. Soils moderately limited by excess water.

Unit IIw-1. Deep, nearly level, somewhat poorly drained silty clay loams on terraces and high bottom land.

Unit IIw-2. Deep, nearly level, moderately well drained to poorly drained, frequently flooded silt loams and silty clay loams on flood plains.

Subclass IIs. Soils moderately limited by very slow permeability.

Unit IIs-1. Deep, nearly level, somewhat poorly drained silty clay loams on uplands.

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

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

Unit IIIe-1. Deep, gently sloping and sloping, well drained and moderately well drained loams, silt loams, and silty clay loams on uplands.

Unit IIIe-2. Deep, gently sloping and sloping, moderately well drained and somewhat poorly drained clay loams and silty clay loams on uplands.

Unit IIIe-3. Deep, gently sloping and sloping, well-drained loams and silt loams that have a thin surface layer; on uplands.

Unit IIIe-4. Deep, gently sloping and sloping, well-drained fine sandy loams on uplands.

Unit IIIe-5. Moderately deep, gently sloping and sloping silty clay loams underlain by limestone and shale; on uplands.

Subclass IIIw. Soils severely limited for cultivation by excess water.

Unit IIIw-1. Deep, very poorly drained, frequently flooded silty clays on flood plains.

Unit IIIw-2. Deep, nearly level to undulating, well drained and excessively drained fine sandy loams and silt loams on flood plains.

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

Subclass IVe. Soils subject to very severe erosion if cultivated and not protected.

Unit IVe-1. Deep, sloping and moderately steep, well drained and moderately well drained loams and silt loams on uplands.

Unit IVe-2. Deep, sloping and moderately steep, moderately well drained silty clay loams on uplands.

Unit IVe-3. Deep, sloping and moderately steep, well drained and moderately well drained loams and silt loams that have a thin surface layer; on uplands.

Unit IVe-4. Deep, sloping and moderately steep, moderately well drained clay loams and silty clay loams on uplands.

Unit IVe-5. Deep, sloping to moderately steep, well-drained silt loams on uplands.

Unit IVe-6. Moderately deep, sloping, well-drained loams underlain by sandstone and sandy shale; on uplands.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife food and cover. (No Class V soils in Leavenworth and Wyandotte Counties.)

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

Subclass VIe. Soils severely limited, chiefly by risk of erosion, unless protective cover is maintained.

Unit VIe-1. Deep, moderately steep, well-drained fine sandy loams and silt loams on uplands.

Unit VIe-2. Shallow and moderately deep, sloping and moderately steep, well drained and somewhat excessively drained loams underlain by sandstone and sandy shale; on uplands.

Subclass VIw. Soils very severely limited for cultivation by excess water.

Unit VIw-1. Deep, nearly level, well-drained loams and silt loams and deep, entrenched channels on flood plains.

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

Subclass VIIe. Soils very severely limited, chiefly by risk of erosion, unless protective cover is maintained.

Unit VIIe-1. Deep, moderately deep, and shallow, moderately steep and steep, well drained, moderately well drained, and somewhat excessively drained silt loams and silty clay loams on uplands.

Class VIII. Soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife food and cover, water supply, or esthetic purposes. (No Class VIII soils in Leavenworth and Wyandotte Counties.)

Predicted yields

The predicted average yields per acre that can be expected for the principal crops grown in the counties are shown in table 2. The yields do not apply to any specific field in any particular year. They indicate what can be expected as an average yield over a period of years. The estimates in the table were based on information obtained from local farmers, various

TABLE 2.—Predicted average yields per acre for principal nonirrigated crops under high-level management

[Only arable soils are listed]

Soil	Corn	Grain sorghum	Soybeans	Wheat	Alfalfa	Tame pasture
	Bu	Bu	Bu	Bu	Tons	AUM ¹
Armster loam, 3 to 8 percent slopes	75	75	36	40	3.2	5.5
Armster loam, 8 to 12 percent slopes	65	70	32	38	3.0	5.0
Bremer silty clay loam	90	100	44	44	4.8	6.5
Elmont silt loam, 3 to 7 percent slopes	80	90	36	40	3.6	6.0
Elmont silt loam, 7 to 12 percent slopes	70	80	34	38	3.4	5.5
Eudora complex, overwash	100	100	42	42	5.0	6.0
Grundy silty clay loam, 1 to 3 percent slopes	85	90	38	42	3.8	6.0
Grundy silty clay loam, 3 to 7 percent slopes	75	80	36	40	3.6	6.0
Gymer silt loam, 3 to 7 percent slopes	75	85	38	42	3.8	6.5
Haig silty clay loam	60	70	34	36	3.4	5.0
Haynie silt loam	95	95	40	40	4.5	5.5
Judson silt loam	110	110	46	48	5.0	7.0
Kennebec silt loam	90	90	36	34	4.0	6.0
Knox silt loam, 7 to 12 percent slopes	75	75	32	40	3.4	6.0
Knox silty clay loam, 7 to 12 percent slopes, eroded	70	70	30	38	3.2	5.5
Konawa fine sandy loam, 3 to 8 percent slopes	65	75	26	34	3.0	5.0
Ladoga silt loam, 4 to 7 percent slopes	90	95	38	42	3.6	5.5
Marshall silt loam, 1 to 4 percent slopes	100	100	42	46	4.0	6.5
Marshall silt loam, 4 to 9 percent slopes	95	100	40	44	3.8	6.5
Marshall silt loam, 9 to 15 percent slopes	90	95	38	42	3.6	6.0
Martin silty clay loam, 4 to 7 percent slopes	75	85	36	40	3.6	6.0
Martin silty clay loam, 7 to 12 percent slopes	70	75	34	35	3.4	5.5
Onawa silty clay loam	85	90	40	40	4.4	6.0
Onawa soils, overwash	90	95	42	44	5.0	6.5
Oska silty clay loam, 3 to 8 percent slopes	65	75	34	38	3.4	5.5
Pawnee clay loam, 1 to 4 percent slopes	70	80	36	40	3.6	5.5
Pawnee clay loam, 4 to 8 percent slopes	65	75	34	36	3.4	5.5
Pawnee clay loam, 4 to 8 percent slopes, eroded	45	55	25	30	2.5	4.5
Sarpy-Haynie complex	60	65	26	32	4.0	4.5
Sharpsburg silty clay loam, 1 to 4 percent slopes	100	100	40	46	4.0	6.5
Sharpsburg silty clay loam, 4 to 8 percent slopes	95	95	38	42	3.8	6.5
Shelby loam, 1 to 4 percent slopes	90	95	38	44	3.8	6.0
Shelby loam, 4 to 8 percent slopes	85	90	36	40	3.6	6.0
Shelby loam, 8 to 12 percent slopes	75	85	34	38	3.4	5.5
Shelby-Pawnee complex, 4 to 8 percent slopes	75	85	34	38	3.6	6.0
Shelby-Pawnee complex, 4 to 8 percent slopes, eroded	60	75	30	36	3.2	5.0
Sibleyville loam, 4 to 8 percent slopes	60	70	28	34	3.0	5.0
Wabash silty clay	70	75	32	30	3.0	5.0
Welda silt loam, 4 to 9 percent slopes	75	80	35	40	3.2	5.5
Welda silt loam, 9 to 15 percent slopes	65	65	28	36	3.0	5.0
Zook silty clay loam	85	90	32	32	3.0	6.0

¹ Animal-unit-months is the number of months in 1 year that 1 acre will support one cow, steer, or horse; five hogs; or seven sheep or goats without injury to the pasture.

agricultural agencies, demonstration plots, and research data.

Only the soils commonly used for crops are listed in table 2. The yields predicted are for a high level of management. Under high level management—

1. Crop varieties are suited to the area.
2. Seeding rates and methods of planting and harvesting are suitable and timely.
3. Control of weeds, diseases, and insects is adequate and timely.
4. Tillage is timely.
5. The amount and kind of fertilizer are based on soil tests.
6. Terraces, contour farming, and grassed waterways conserve moisture and control runoff.
7. Selected cropping systems and crop residue management control water erosion and soil blowing and keep the soil in good physical condition.

Woodland

The soils of Leavenworth and Wyandotte Counties that have potential for producing woodland have been classified in woodland suitability groups to assist landowners in planning the use of their soils for wood crops. Each group is made up of soils that are suited to the same kinds of trees, need approximately the same kind of management under similar vegetation, and have about the same potential productivity.

Each woodland group is identified by a three-part symbol, such as 3o1, 4w2, or 5r2. The first part of the symbol, always a number, indicates relative potential productivity of the soils in the group: 1 indicates very high; 2 indicates high; 3 indicates moderately high; 4 indicates moderate; and 5 indicates low. These ratings are based on field determinations of average site index. Site index is the height, in feet, that the dominant trees of a given species, on a specified kind of soil, reach in a natural, unmanaged stand in a

TABLE 3.—Wood crops and
[The species in italics in the column "Important

Woodland suitability group and map symbols	Potential productivity		Trees suitable for planting
	Important trees	Site index range	
Group 2o1: Deep, well-drained loamy soils on bottom land; rarely flooded; high to very high available water capacity; moderate productivity. Eu, Hy, Ju.	<i>Eastern cottonwood</i> ----- American sycamore ----- Black walnut ----- Green ash -----	100-105 95-100 70-80 -----	Black walnut, eastern cottonwood, green ash.
Group 3w2: Moderately well drained loamy soils on bottom land; flooded frequently; high available water capacity; moderate productivity. Aa, Ke.	<i>White oak</i> ----- Bur oak ----- Black walnut ----- Eastern cottonwood -----	60-70 60-70 70-80 -----	Black walnut, eastern cottonwood, green ash, hackberry.
Group 4o1: Deep, well drained and moderately well drained soils on uplands; surface layer of silt loam, loam, and fine sandy loam; subsoil of silty clay loam and clay loam; high available water capacity; moderately low productivity. Ac, Ad, Ae, Kh, Km, Ko, La, Wc, Wd.	<i>Black oak</i> ----- White oak ----- Black walnut ----- American basswood -----	55-65 50-60 60-70 -----	Black walnut, green ash, hackberry, red oak.
Group 4r2: Deep, strongly sloping, moderately steep, and steep, well-drained loamy soils on uplands; subsoil of clay loam and silty clay loam; low to medium fertility; high available water capacity; low to moderately low productivity. Kk, Kn, Kw.	<i>Black oak</i> ----- White oak ----- Shagbark hickory -----	55-65 50-60 -----	Hackberry, green ash
Group 4s2: Deep, well-drained and excessively drained sandy and loamy soils on bottom land; subject to flooding; low and medium fertility; low to high available water capacity; moderately low productivity. Sa.	<i>Eastern cottonwood</i> ----- American sycamore ----- Bur oak -----	75-85 ----- 50-60	Cottonwood
Group 4w2: Deep, somewhat poorly drained to poorly drained soils on bottom land and low terraces; bottom land subject to flooding; surface layer of silty clay loam; slow permeability; slow runoff; moderately low productivity. Br, On, Oo, Zo.	<i>Eastern cottonwood</i> ----- American sycamore ----- Bur oak -----	75-85 ----- 50-60	Cottonwood, green ash
Group 5d2: Shallow and moderately deep, sloping to steep, moderately well drained, well drained, and somewhat excessively drained loamy soils on uplands; low or medium fertility; low and very low available water capacity; low productivity. Ba, Gc, Gs.	<i>White oak</i> ----- Black oak ----- Black walnut -----	40-50 45-55 45-55	Hackberry, green ash
Group 5w3: Deep, nearly level, very poorly drained soils on bottom land; subject to flooding; slow runoff; very slow permeability; low productivity. Wa.	<i>Eastern cottonwood</i> ----- Pin oak ----- American sycamore -----	70-75 60-65 -----	Eastern cottonwood

stated number of years. For the merchantable hardwoods and softwoods in the counties, the site index is the height reached in 50 years, except for cottonwood, which is based on the height reached in 30 years.

The five ratings are based on field determination of the average site index of an indicator forest type or species. Site indexes are based on recognized site index curves for upland oaks (9) and cottonwood (5).

The second part of the symbol identifying a woodland group is a small letter. This letter indicates an important soil property that imposes a slight to severe hazard or limitation in managing the soils of the group for wood crops. A letter *c* shows that the main limitation is the kind or amount of clay in the upper part of the soils; *o* shows that the soils have few limitations that restrict their use for trees; *r* shows that the main limitation is steep slopes; *s* shows that

the soils are sandy and dry, have little or no difference in texture between surface layer and subsoil, have low available water capacity, and generally have a low supply of plant nutrients; *w* shows that water in or on the soil, either seasonally or year round, is the chief limitation; *d* shows that the main limitation is a restricted rooting depth, because the soil is shallow over rock or shale.

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

The hazards or limitations that affect management of soils for woodland in Leavenworth and Wyandotte

soil-related limitations

trees" is the indicator forest type or species]

Seedling mortality	Plant competition	Equipment limitations	Erosion hazard	Windthrow hazard
Slight -----	Slight -----	Slight -----	Slight -----	Slight.
Moderate: flooding ---	Severe: vines and weed trees.	Slight -----	Slight -----	Slight.
Slight: periodically droughty.	Slight -----	Slight: restricted during wet periods.	Slight: erosion control needed along roads.	Slight: care needed in opening dense stands.
Slight: periodically droughty.	Slight -----	Moderate -----	Slight: erosion control needed along roads.	Slight.
Moderate: flooding; periodically droughty.	Slight -----	Moderate: sandy texture.	Slight -----	Moderate.
Moderate: flooding ---	Moderate: vines and weed trees.	Moderate: soil compacts when wet.	Slight -----	Slight.
Moderate: periodically droughty.	Slight -----	Moderate -----	Slight: erosion control needed along roads.	Slight to moderate.
Moderate -----	Moderate -----	Severe: very poorly drained.	Slight -----	Moderate.

Counties are windthrow hazard, erosion hazard, equipment limitations, seedling mortality, and plant competition.

The woodland suitability groups of Leavenworth and Wyandotte Counties are briefly described in table 3. The hazards of windthrow and erosion, the equipment limitation, seedling mortality, and the risk of competition from undesirable plants are expressed as slight, moderate, or severe.

Windthrow hazard measures the effect of the soils on root development and the ability of the soil to hold trees firmly. The hazard is *slight* if the root zone is more than 20 inches deep and the tree withstands most wind; the hazard is *moderate* if the root zone is 10 to 20 inches deep and some trees are blown down during periods of excessive soil wetness and strong wind; it is *severe* if the root zone is less than 10 inches

deep and trees will not stand alone in strong wind.

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

Equipment limitation is based on soil characteristics that restrict or prohibit the use of equipment commonly used in tending and harvesting the trees. In Leavenworth and Wyandotte Counties the most limiting are drainage, depth to water table, slope, and texture of the surface layer. In rating the equipment limitation, *slight* indicates no restriction in the kind of



Figure 15.—Native stands of timber on Welda and Ladoga silt loams.

equipment or in the time of year it is used; *moderate* indicates that use of equipment is restricted for less than 3 months of the year; and *severe* indicates that special equipment is needed and its use is restricted for more than 3 months of the year.

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

Plant competition is based on the degree to which unwanted plants invade openings in the tree canopy.

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

Table 3 shows the woodland suitability groups, the management limitations to be considered, and some of the preferred timber species and their average site indexes. Figure 15 shows a typical wooded area on Welda and Ladoga soils.

Wildlife

The kinds and numbers of wildlife are determined by climate, soils, and land use. Of these factors the land use is most subject to change. If land use is

TABLE 4.—Potential of the soils for kinds of wildlife

Soil series and map symbols	Kinds of wildlife		
	Openland	Woodland	Wetland
Alluvial land: Aa	Fair	Good	Good.
Armster: Ac, Ad, Ae	Good	Good	Very poor.
Basehor: Ba	Fair	Fair	Very poor.
Bremer: Br	Good	Good	Good.
Elmont: Ec, Ed	Good	Good	Very poor.
Eudora: Eu	Good	Good	Poor.
Gospport: Gc, Gs	Poor	Fair	Very poor.
For Sogn part of Gs, see Sogn series.			
Grundy: Gt, Gu	Good to fair	Good	Poor.
Gymer: Gy	Good	Good	Very poor.
Haig: Hg	Good	Good	Fair.
Haynie: Hy	Good	Good	Poor.
Judson: Ju	Good	Good	Poor.
Kennebec: Ke	Good	Good	Fair.
Knox: Kh, Kk, Km, Kn	Good to poor	Good to fair	Very poor.
Konawa: Ko, Kw	Fair	Good	Very poor.
Ladoga: La	Good	Good	Very poor.
Marshall: Mb, Mc, Md	Good	Good	Poor to very poor.
Martin: Mn, Mr, Ms	Good to fair	Good	Very poor.
Onawa: On, Oo	Good	Good	Good.
Oska: Os	Good	Good	Very poor.
Pawnee: Pb, Pc, Pe	Good	Good	Poor.
Sarpy: Sa	Poor	Poor	Very poor.
For Haynie part of Sa, see Haynie series.			
Sharpsburg: Sb, Sc	Good	Good	Poor.
Shelby: Se, Sh, Sm, Sp, Ss	Good	Good	Poor.
For Pawnee part of Sp and Ss, see Pawnee series.			
Sibleyville: Sy	Good	Good	Very poor.
Sogn	Poor	Fair	Very poor.
Mapped only with Gospport soils.			
Vinland: Vs	Poor	Fair	Very poor.
For Sibleyville part of Vs, see Sibleyville series.			
Wabash: Wa	Poor	Poor	Good.
Welda: Wc, Wd	Good	Good	Very poor.
Zook: Zo	Fair	Fair	Good.

changed, the wildlife in the area is also likely to change.

Wildlife is classified as *openland*, *woodland*, and *wetland*.

Openland wildlife normally inhabits cropland, pastures, meadows, and odd fields of herbaceous vegetation. Examples are pheasant, quail, meadow lark, cottontail rabbit, coyote, and badger.

Woodland wildlife inhabits wooded areas of trees and shrubs. The more common kinds are the white-tailed deer, squirrel, raccoon, gray fox, woodpeckers, and thrushes.

Wetland wildlife inhabits ponds, marshes, rivers, streams, and swamps. Examples are ducks, herons, rails, kingfishers, shore birds, beaver, mink, and muskrat.

The suitability of each soil in Leavenworth and Wyandotte Counties for producing food and cover for the various kinds of wildlife is rated in table 4. The levels of suitability are expressed as *good*, *fair*, *poor*, and *very poor*.

A rating of *good* indicates few or no limitations. Habitat can be easily improved, maintained, or created.

A rating of *fair* indicates moderate limitations. Habitat can be improved, maintained, or created only with some difficulty and expense, and fairly frequent attention can be required to ensure satisfactory results.

A rating of *poor* indicates severe limitations. Habitat can be difficult and expensive to improve, maintain, or create, and management can be difficult and expensive and results unpredictable.

A rating of *very poor* indicates that habitat is generally impractical to improve, maintain, or create and unsatisfactory results are probable.

The soils of Leavenworth and Wyandotte Counties provide suitable habitat for many kinds of animals and birds. The densities of all wildlife species decrease in the highly developed areas of the counties. The section "General Soil Map" tells something about the landscape and the soils in each association. The general soil map at the back of this publication shows the location of each association in the two counties. Information on individual soils can be found in the section "Descriptions of the Soils."

The most important game bird in the survey area is the bobwhite (quail). The average density of bobwhite on the Kennebec-Bremer-Wabash and the Onawa-Haynie-Eudora associations is one bird for every 2 acres. Pheasants are scarce and scattered throughout the counties. The mourning dove, a popular game bird in Kansas, is moderately abundant in both counties. It depends heavily on seeds as a source of food, chiefly herbaceous habitat and small grain crops. Numerous farm ponds in both counties provide the water needs. The ponds are also used by migrating waterfowl.

TABLE 5.—Degree and kind of limitation for recreational facilities

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Alluvial land: Aa ----- Armster: Ac, Ad, Ae -----	Severe: flooding ----- Moderate: moderately slow permeability; slope is more than 8 percent in places.	Severe: flooding ----- Slight if slope is 3 to 8 percent, moderate if more than 8 percent.	Severe: flooding ----- Moderate if slope is less than 6 percent, severe if more than 6 percent; moderately slow permeability.	Severe: flooding. Slight.
Basehor: Ba -----	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Severe: slope; bedrock within a depth of 20 inches.	Slight.
Bremer: Br -----	Moderate: wet; slow permeability.	Moderate: wet -----	Moderate: wet; slow permeability.	Moderate: wet.
Elmont: Ec, Ed -----	Moderate: moderately slow permeability; slope is more than 8 percent in places.	Slight if slope is 3 to 8 percent, moderate if more than 8 percent.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; moderately slow permeability.	Slight.
Eudora: Eu -----	Slight if protected from flooding, severe if subject to flooding.	Slight if protected from flooding, moderate if subject to flooding.	Slight if protected from flooding, moderate if subject to flooding.	Slight.
Gosport: Gc, Gs ----- For Sogn part of Gs, see Sogn series.	Severe: very slow permeability.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Severe: very slow permeability; slope.	Slight if slope is less than 15 percent, moderate if more than 15 percent.
Grundt: Gt, Gu -----	Moderate: wet; slow permeability; silty clay loam surface layer.	Moderate: wet; silty clay loam surface layer.	Moderate if slope is less than 6 percent, severe if more than 6 percent; wet; slow permeability; silty clay loam surface layer.	Moderate: wet; silty clay loam surface layer.
Gymer: Gy -----	Moderate: moderately slow permeability.	Slight -----	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; moderately slow permeability.	Slight.
Haig, Hg -----	Severe: slow permeability.	Moderate: wet -----	Severe: very slow permeability.	Moderate: wet.
Haynie: Hy -----	Slight if protected from flooding, severe if subject to flooding.	Slight if protected from flooding, moderate if subject to flooding.	Slight if protected from flooding, moderate if subject to flooding.	Slight.
Judson: Ju -----	Slight -----	Slight -----	Slight -----	Slight.
Kennebec: Ke -----	Severe: flooding -----	Moderate: flooding -----	Moderate: flooding -----	Moderate: flooding.
Knox: Kh, Kk, Km, Kn -----	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Severe: slope -----	Moderate if slope is 15 to 25 percent, severe if more than 25 percent.
Konawa: Ko, Kw -----	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Moderate if slope is 3 to 6 percent, severe if more than 6 percent.	Moderate: slope is more than 15 percent in places.
Ladoga: La -----	Moderate: moderately slow permeability.	Slight -----	Moderate if slope is 2 to 6 percent, severe if more than 6 percent.	Slight.
Marshall: Mb, Mc, Md -----	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent.	Slight.
Martin: Mn, Mr, Ms -----	Moderate if slope is 8 to 15 percent; wet; slow permeability; silty clay loam surface layer.	Moderate if slope is 8 to 15 percent; wet; silty clay loam surface layer.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; wet; slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Onawa: On, Oo -----	Severe: wet; slow permeability; silty clay loam surface layer; flooding.	Moderate: wet; silty clay loam surface layer; flooding.	Moderate: wet; slow permeability; silty clay loam surface layer; flooding.	Moderate: wet; silty clay loam surface layer.
Oska: Os -----	Moderate: slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; slow permeability; silty clay loam surface layer; bedrock within depth of 40 inches.	Moderate: silty clay loam surface layer.
Pawnee: Pb, Pc, Pe -----	Moderate: wet; slow permeability; clay loam surface layer.	Moderate: wet; clay loam surface layer.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; wet; slow permeability; clay loam surface layer.	Moderate: clay loam surface layer.

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

Soil series and map symbols	Camp areas	Picnic areas	Playgrounds	Paths and trails
Sarpy: Sa ----- For Haynie part, see Haynie series.	Severe: flooding -----	Moderate: flooding ----	Moderate: flooding ----	Slight.
Sharpsburg: Sb, Sc -----	Moderate: moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; moderately slow permeability; silty clay loam surface layer.	Moderate: silty clay loam surface layer.
Shelby: Se, Sh, Sm, Sp, Ss. For Pawnee parts of Sp and Ss, see Pawnee series.	Moderate: moderately slow permeability.	Slight if slope is less than 8 percent, moderate if more than 8 percent.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; moderately slow permeability.	Slight.
Sibleyville: Sy -----	Slight if slope is less than 8 percent, moderate if more than 8 percent.	Slight if slope is less than 8 percent, moderate if more than 8 percent.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; depth to bedrock.	Slight.
Sogn Mapped only with Gosport soils.	Severe: rockiness -----	Severe: rockiness -----	Severe: rockiness -----	Severe: rockiness.
Vinland: Vs ----- For Sibleyville part, see Sibleyville series.	Moderate if slope is 5 to 12 percent.	Moderate if slope is 5 to 12 percent.	Severe: slope; depth to bedrock.	Slight.
Wabash: Wa -----	Severe: wet; very slow permeability; silty clay surface layer; flooding.	Severe: wet; silty clay surface layer.	Severe: wet; very slow permeability; silty clay surface layer.	Severe: wet; silty clay surface layer.
Welda: Wc, Wd -----	Moderate if slope is 8 to 15 percent; moderately slow permeability.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.	Moderate if slope is 2 to 6 percent, severe if more than 6 percent; moderately slow permeability.	Slight.
Zook: Zo -----	Severe: flooding -----	Moderate: wet; flooding; silty clay loam surface layer.	Moderate: wet; permeability; flooding; silty clay loam surface layer.	Moderate: wet; flooding; silty clay loam surface layer.

The Leavenworth County State Lake in the Gosport-Sogn association and the Wyandotte County State Lake in the Knox-Ladoga soil association provide large numbers of game fish and are developed for such recreational activities as picnicking, camping, sightseeing, and fishing. Good fishing is also provided by the numerous private water impoundments and the rivers and streams in both counties.

The main game fish are bass, bluegill, and channel catfish; all are available from the State fish hatcheries for stocking new and renovated ponds. Crappie, bullhead, and carp provide additional fishing in the rivers, streams, and larger lakes.

Whitetailed deer, the only big game animal in both counties, is moderately abundant in number, and population is increasing. Habitat for the whitetailed deer is available on all soil associations, but the best habitat is on soils in the alluvium along the Kansas River, the Missouri River, Stranger Creek, and their major tributaries. During the fall hunting season, hunters are allowed to harvest part of the surplus animals.

Cottontail rabbits frequent all soil associations in both counties. The most productive habitat is on the Kennebec-Bremer-Wabash and Onawa-Haynie-Eudora association. The carrying capacity for the cottontail is increased where the proper kinds of food and cover are well interspersed. A good habitat has one

cottontail per acre. Heavy bushy thickets are required to shelter a large population of rabbits.

Populations of squirrel, both fox and gray, are moderate in both counties. Squirrels are most abundant on soils in the alluvium along the major drainageways, in both counties.

Developing habitat for wildlife requires proper location of the various types of plant cover on suitable soils. Technical assistance in planning wildlife developments and in determining suitable vegetation for plantings can be obtained from the office of the Soil Conservation Service. Additional information and assistance can be obtained from the Bureau of Sports, Fisheries and Wildlife; the Kansas Forestry Fish and Game Commission; and from the Extension Service.

Recreation⁴

Leavenworth and Wyandotte Counties are easily accessible by automobile and provide many recreational opportunities. U.S. Interstate No. 70 connects the eastern and western parts of Kansas, and the Kansas Turnpike connects Wichita, Topeka, Lawrence, and Kansas City. Leavenworth is connected by

⁴ Prepared by JACK W. WALSTROM, biologist, and LARRY D. ZAVESKY, soil scientist, Soil Conservation Service.

TABLE 6.—*Estimates of 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 for referring to other series that appear in the first column. The

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Water table			Unified	AASHO
	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>			
Alluvial land: Aa. No valid estimates can be made. Variable material.						
Armster: Ac, Ad, Ae	>60	>10	0-10 10-60	Loam Clay loam	CL, ML-CL CL	A-4 or A-6 A-6 or A-7
Basehor: Ba	<20	>10	0-11 11	Loam Sandstone.	ML	A-4
Bremer: Br	>60	>5	0-13 13-34 34-70	Silty clay loam Silty clay Silty clay loam	CL or CH CH CL or CH	A-6 or A-7 A-7 A-6 or A-7
Elmont: Ec, Ed	>40	>10	0-15 15-65	Silt loam Silty clay loam	CL, ML-CL CL	A-4 or A-6 A-6 or A-7
Eudora: Eu	>60	>5	0-9 9-12 12-34 34-65	Very fine sandy loam Loamy very fine sand Silt loam Very fine sandy loam	ML-CL or ML SM or ML ML ML-CL or ML	A-4 A-4 A-4 A-4
*Gosport: Gc, Gs For Sogn part of Gs, see Sogn series.	20-40	>5	0-6 6-23 23	Silt loam Silty clay Shale.	ML or CL CH	A-4 or A-6 A-7
Grundy: Gt, Gu	>60	>10	0-15 15-30 30-65	Silty clay loam Silty clay Silty clay loam	ML-CL or CL CH CL or CH	A-6 A-7 A-6 or A-7
Gymer: Gy	>60	>10	0-7 7-60	Silt loam Silty clay loam	ML-CL or CL	A-4 or A-6 A-6 or A-7
Haig: Hg	>60	>10	0-9 9-45 45-60	Silty clay loam Silty clay Silty clay loam	CL CH CL or CH	A-6 or A-7 A-7 A-6 or A-7
Haynie: Hy	>60	>5	0-26 26-60	Silt loam Very fine sandy loam	ML ML-CL or ML	A-4 A-4
Judson: Ju	>60	>10	0-30 30-70	Silt loam Silty clay loam	ML-CL or CL	A-4 or A-6 A-6 or A-7
Kennebec: Ke	>60	>5	0-45 45-72	Silt loam Silty clay loam	ML-CL or CL	A-4 or A-6 A-6 or A-7
Knox: Kh, Kk, Km, Kn	>60	>10	0-6 6-60	Silt loam Silty clay loam	ML ML-CL or CL	A-4 A-4 or A-6
Konawa: Ko, Kw	>60	>10	0-19 19-47 47-60	Fine sandy loam Clay loam Loam	SM or ML CL ML-CL	A-4 A-6 A-4
Ladoga: La	>60	>10	0-7 7-60	Silt loam Silty clay loam	ML-CL CL or CH	A-4 A-6 or A-7
Marshall: Mb, Mc, Md	>60	>10	0-13 13-46 46-65	Silt loam Silty clay loam Silt loam	ML-CL or CL ML-CL or CL	A-6 or A-7 A-6 or A-7 A-6 or A-7

significant in engineering

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions symbol > means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200				
				<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
	100	90-98	65-90	0.6-2.0	0.20-0.22	5.6-7.3	Moderate.
	100	90-98	70-85	0.2-0.6	0.15-0.19	5.1-7.3	Moderate to high.
	100	85-95	60-75	2.0-6.0	0.17-0.21	5.1-6.5	Low.
	100	95-100	85-95	0.2-0.6	0.21-0.23	6.1-7.3	Moderate to high.
	100	95-100	90-95	0.06-0.2	0.15-0.18	5.6-6.5	High.
	100	95-100	85-95	0.06-0.2	0.18-0.20	5.6-7.3	Moderate to high.
	100	90-100	70-90	0.6-2.0	0.22-0.24	5.6-6.5	Low.
	100	95-100	85-95	0.2-0.6	0.18-0.20	5.6-7.3	Moderate.
	100	85-95	51-65	2.0-6.0	0.20-0.22	6.6-7.3	Low.
	100	90-95	40-60	2.0-6.0	0.09-0.11	6.6-7.3	Low.
	100	90-100	70-90	0.6-2.0	0.20-0.22	7.3-8.4	Low.
	100	90-95	51-65	2.0-6.0	0.17-0.19	7.3-8.4	Low.
	100	90-100	70-90	0.6-2.0	0.22-0.24	5.6-6.5	Low.
	100	95-100	90-95	<0.06	0.15-0.17	4.5-5.5	Moderate.
	100	95-100	95-99	0.2-0.6	0.21-0.23	5.6-6.5	Moderate.
	100	95-100	90-98	0.06-0.2	0.16-0.19	5.1-6.5	High.
	100	95-100	95-99	0.2-0.6	0.15-0.17	5.6-7.3	Moderate to high.
	100	90-100	70-90	0.6-2.0	0.22-0.24	5.6-6.5	Moderate.
	100	95-100	85-95	0.2-0.6	0.16-0.19	5.6-6.5	Moderate to high.
	100	95-100	85-95	0.2-0.6	0.21-0.23	6.1-7.3	Moderate.
	100	95-100	90-95	0.06-0.2	0.14-0.17	6.1-7.3	High.
	100	95-100	85-95	0.06-0.2	0.18-0.20	6.1-7.3	Moderate.
	100	90-100	70-90	0.6-2.0	0.22-0.24	7.4-8.4	Low.
	100	90-95	51-65	2.0-6.0	0.17-0.19	7.4-8.4	Low.
	100	90-100	70-90	0.6-2.0	0.22-0.24	6.1-7.3	Moderate.
	100	95-100	85-90	0.6-2.0	0.18-0.20	5.6-6.5	Moderate.
	100	90-100	70-90	0.6-2.0	0.22-0.24	6.1-7.3	Moderate.
	100	95-100	85-90	0.6-2.0	0.18-0.20	6.1-7.3	Moderate.
	100	95-100	90-100	0.6-2.0	0.22-0.24	5.6-6.5	Low.
	100	95-100	90-100	0.6-2.0	0.16-0.18	5.6-6.5	Low to moderate.
	100	75-85	40-55	2.0-6.0	0.16-0.18	5.6-6.5	Low.
	100	90-100	70-80	0.6-2.0	0.15-0.19	5.1-6.0	Moderate.
	100	85-95	60-75	0.6-2.0	0.17-0.19	5.1-6.0	Moderate.
	100	95-100	80-98	0.6-2.0	0.22-0.24	5.6-7.3	Low to moderate.
	100	95-100	85-98	0.2-0.6	0.18-0.20	5.1-7.3	Moderate to high.
	100	90-100	85-99	0.6-2.0	0.22-0.24	5.6-6.5	Moderate.
	100	95-100	95-100	0.6-2.0	0.18-0.20	5.6-6.5	Moderate.
	100	90-100	95-100	0.6-2.0	0.20-0.21	6.1-7.3	Moderate.

TABLE 6.—*Estimates of 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
for referring to other series that appear in the first column.

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Water table			Unified	AASHO
	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>			
Martin: Mn, Mr, Ms -----	>60	>10	0-8 8-75	Silty clay loam ----- Silty clay -----	CL, ML-CL CH	A-6 or A-7 A-7
Onawa: On, Oo -----	>60	>4	0-25 25-60	Silty clay ----- Silt loam -----	CH CL or ML- CL	A-7 A-4 or A-6
Oska: Os -----	20-40	>5	0-9 9-38 38	Silty clay loam ----- Silty clay loam ----- Limestone.	CL CL or CH	A-6 or A-7 A-6 or A-7
Pawnee: Pb, Pc, Pe -----	>60	>10	0-12 12-49 49-60	Clay loam ----- Clay loam ----- Clay loam -----	CL CL or CH CL	A-6 A-6 or A-7 A-6
*Sarpy: Sa ----- For Haynie part, see Haynie series.	>60	>5	0-9 9-60	Loamy fine sand ----- Fine sand -----	SM SM	A-2 or A-4 A-2
Sharpsburg: Sb, Sc -----	>60	>10	0-15 15-42 42-60	Silty clay loam ----- Silty clay loam ----- Silty clay loam -----	ML-CL or CL CL or CH ML-CL or CL	A-6 or A-7 A-7 A-6 or A-7
*Shelby: Se, Sh, Sm, Sp, Ss ----- For Pawnee part of Sp and Ss, see Pawnee series.	>60	>10	0-13 13-40 40-75	Loam or clay loam ----- Clay loam ----- Clay loam -----	CL CL CL	A-6 A-6 or A-7 A-6 or A-7
Sibleyville: Sy -----	20-40	>5	0-13 13-28 28-32 32	Loam ----- Clay loam ----- Loam ----- Sandstone.	ML or CL CL, ML-CL ML or CL	A-4 or A-6 A-6 A-4
Sogn ----- Mapped only with Gosport soils.	<20	>5	0-16 16	Silty clay loam ----- Limestone.	CL	A-6 or A-7
*Vinland: Vs ----- For Sibleyville part, see Sibleyville series.	<20	>5	0-18 18	Loam ----- Sandstone.	ML or CL	A-4 or A-6
Wabash: Wa -----	>60	>5	0-60	Silty clay -----	CH	A-7
Welda: Wc, Wd -----	>60	>10	0-12 12-48 48-70	Silt loam ----- Silty clay loam ----- Silty clay loam -----	ML, ML-CL CL ML-CL, CL	A-4 A-7 A-6 or A-7
Zook: Zo -----	>60	>5	0-22 22-52 52-76	Silty clay loam ----- Silty clay ----- Silty clay loam -----	CL CH CL or CH	A-6 or A-7 A-7 A-6 or A-7

significant in engineering—Continued

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions
The symbol > means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4	No. 10	No. 40	No. 200				
				<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
	100	95-100	70-90	0.2-0.6	0.21-0.23	5.6-6.5	Moderate.
	100	95-100	75-95	0.06-0.2	0.15-0.18	5.6-7.3	High.
	100	95-100	90-95	0.06-0.2	0.12-0.14	7.4-8.4	High.
	100	90-100	70-90	0.6-2.0	0.20-0.22	7.4-8.4	Low to moderate.
	100	95-100	85-95	0.2-0.6	0.21-0.23	5.6-6.5	Moderate.
	100	95-100	85-95	0.06-0.2	0.16-0.18	5.6-6.5	High.
	100	90-100	65-80	0.6-2.0	0.17-0.19	5.6-6.5	Moderate.
	100	90-100	70-80	0.06-0.2	0.15-0.19	5.6-7.3	Moderate to high.
	100	90-100	70-80	0.2-0.6	0.14-0.16	7.3-8.4	Moderate to high.
	100	65-85	30-50	>6.0	0.10-0.12	6.6-7.8	Low.
	100	55-80	15-35	>6.0	0.06-0.08	6.6-7.8	Low.
	100	95-100	85-95	0.6-2.0	0.21-0.23	5.6-7.3	Moderate.
	100	95-100	85-95	0.2-0.6	0.18-0.20	5.1-6.5	Moderate to high.
	100	95-100	85-95	0.6-2.0	0.18-0.20	5.6-7.3	Moderate.
95-100	90-95	75-90	75-95	0.6-2.0	0.17-0.19	5.6-7.3	Moderate.
90-100	85-98	75-90	55-70	0.2-0.6	0.15-0.19	5.1-6.5	Moderate.
90-100	85-98	75-90	55-70	0.2-0.6	0.14-0.16	6.6-8.4	Moderate.
100	95-100	80-90	60-75	0.6-2.0	0.18-0.21	5.6-7.3	Low.
95-100	90-95	80-90	55-70	0.6-2.0	0.16-0.18	5.6-6.5	Low.
95-100	90-95	80-90	60-75	0.6-2.0	0.15-0.17	5.6-7.3	Low.
90-100	80-95	75-90	65-85	0.6-2.0	0.18-0.23	6.1-8.4	Moderate to high.
95-100	85-100	70-90	65-75	0.6-2.0	0.18-0.21	5.6-6.5	Low.
	100	98-100	95-100	<0.06	0.12-0.14	6.1-7.8	High.
	100	90-100	70-90	0.6-2.0	0.22-0.24	5.6-7.3	Low.
	100	95-100	85-95	0.2-0.6	0.18-0.20	5.1-6.5	Moderate.
	100	90-100	70-85	0.2-0.6	0.18-0.20	5.1-6.5	Low to moderate.
	100	95-100	85-95	0.2-0.6	0.21-0.23	6.1-7.3	Moderate.
	100	95-100	90-95	0.06-0.2	0.15-0.18	6.1-7.3	High.
	100	95-100	85-95	0.06-0.2	0.18-0.20	6.1-7.3	Moderate to high.

TABLE 7.—*Engineering*

[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 for referring to other series

Soil series and map symbol	Suitability as a source of—		Soil features affecting—	
	Road fill and subgrade	Topsoil	Highway location	Pond reservoir areas
Alluvial land: Aa. No interpretations. Variable material. Armster: Ac, Ad, Ae -----	Fair road fill; fair shear strength; poor subgrade; low support; medium to high plasticity.	Fair: loam texture; 8 to 16 inches thick; low organic-matter content.	Low support; difficult to revegetate.	Moderately slow permeability; seepage potential; gravel pockets; moderately steep.
Basehor: Ba -----	Poor: sandstone within a depth of 20 inches.	Poor: loam texture; 8 to 16 inches thick; sandstone within a depth of 20 inches; difficult to reclaim.	Sandstone within a depth of 20 inches.	Sandstone within a depth of 20 inches; seepage potential; sandy texture.
Bremer: Br -----	Fair road fill; fair shear strength; poor subgrade; low support; high plasticity.	Fair: silty clay loam texture; 8 to 16 inches thick.	Poor workability; slow internal drainage.	Slow permeability -----
Elmont: Ec, Ed -----	Fair road fill; fair shear strength; fair subgrade; medium support; medium plasticity.	Fair: silt loam texture; 8 to 16 inches thick.	All features favorable -----	Moderately slow permeability; seepage in places.
Eudora: Eu -----	Good road fill and subgrade.	Good: high organic-matter content.	Erodible; some areas subject to flooding.	Moderate to rapid permeability below a depth of 40 inches; seepage potential.
*Gosport: Gc, Gs ----- For Sogn part of Gs, see Sogn series.	Fair road fill; fair shear strength; fair subgrade; medium support.	Poor: less than 8 inches thick; slope is more than 15 percent in places.	Steep slope; shale within a depth of 40 inches; difficult to establish vegetation.	Shale within a depth of 40 inches; steep.
Grundy: Gt, Gu -----	Fair road fill; fair shear strength; poor subgrade; medium support; high plasticity.	Fair: silty clay loam texture; 8 to 16 inches thick.	Poor workability -----	Slow permeability -----
Gymer: Gy -----	Fair road fill; fair shear strength; fair subgrade; medium support; medium plasticity.	Fair: silt loam and silty clay loam texture; 8 to 16 inches thick.	Erodible -----	Moderately slow permeability.
Haig: Hg -----	Fair road fill; fair shear strength; poor subgrade; low support; high plasticity.	Fair: silty clay loam texture; 8 to 16 inches thick.	Slow internal drainage; nearly level; poor workability.	Very slow permeability
Haynie: Hy -----	Good road fill and subgrade.	Good -----	Erodible; subject to flooding.	Moderate permeability below a depth of 40 inches; seepage potential.
Judson: Ju -----	Good road fill; fair subgrade; medium support.	Good: high organic-matter content.	Erodible -----	Moderate permeability
Kennebec: Ke -----	Good road fill; fair subgrade; medium support.	Good: high organic-matter content.	Erodible -----	Moderate permeability; subject to flooding most of the time.

interpretations

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions that appear in the first column]

Soil features affecting—Continued				
Embankments, dikes, and levees	Drainage of crops and pasture	Irrigation	Terraces and diversions	Waterways
Fair to poor stability and compaction; fair shear strength; impervious; high shrink-swell potential.	Moderately well drained; moderately slow permeability; gently sloping to moderately steep.	Low intake rate; high available water capacity; medium fertility; gently sloping to moderately steep.	Short irregular slopes; small irregular landscape.	Gently sloping to moderately steep; erodible; difficult to establish vegetation.
Good stability; low shrink-swell potential; limited fill material; erodible.	Not applicable -----	Not applicable -----	Shallow over bedrock; low fertility; slope.	Shallow over bedrock; low fertility; slope; erodible.
Fair to poor stability and compaction; fair shear strength; impervious; high shrink-swell potential.	Somewhat poorly drained; level and nearly level; slow permeability.	Low intake rate; high available water capacity; high fertility; level and nearly level.	Level and nearly level --	Level and nearly level.
Fair to good stability and compaction; fair shear strength; moderate shrink-swell potential; impervious.	Well drained; moderately slow permeability; gently sloping to moderately steep.	Medium intake rate; high available water capacity; gently sloping to moderately steep.	Moderately steep; seepy in places.	Seepy in places.
Good stability, compaction and shear strength; poor resistance to piping; low shrink-swell potential; erodible; moderately impervious.	Well drained; nearly level.	Medium intake rate; high available water capacity; soil blowing; nearly level.	Nearly level -----	Nearly level.
Fair to poor stability and compaction; fair shear strength; medium shrink-swell potential; possible sliding; impervious; limited fill material.	Not applicable -----	Not applicable -----	Not applicable -----	Not applicable.
Fair to poor stability and compaction; fair shear strength; high shrink-swell potential; impervious.	Somewhat poorly drained; slow permeability; seepy in places; gently sloping and sloping.	Low intake rate; high available water capacity; gently sloping and sloping.	Dense, clayey subsoil; very hard when dry; construction difficult.	All features favorable.
Fair to good stability and compaction; fair shear strength; moderate shrink-swell potential; impervious.	Well drained; moderately slow permeability; gently sloping and sloping.	Low intake rate; high available water capacity; gently sloping and sloping.	All features favorable ---	All features favorable.
Fair to poor stability and compaction; fair shear strength; impervious; high shrink-swell potential.	Somewhat poorly drained; very slow permeability; slow runoff; nearly level and gently sloping.	Low intake rate; moderate available water capacity; nearly level and gently sloping.	Clayey subsoil; very hard when dry; construction difficult.	Clayey subsoil; difficult to establish vegetation.
Poor stability, compaction, and shear strength; moderately impervious; poor resistance to piping; low shrink-swell potential; erodible.	Well drained; nearly level.	Medium intake rate; subject to flooding in a few places; nearly level; high available water capacity.	Nearly level -----	Soil blowing.
Fair to good stability and compaction; good shear strength; moderate shrink-swell potential; impervious.	Well drained; moderate permeability; nearly level.	Medium intake rate; very high available water capacity; high fertility; nearly level.	All features favorable ---	All features favorable.
Fair to good stability and compaction; good shear strength; moderate shrink-swell potential; impervious.	Subject to flooding most of the time; moderately well drained; nearly level.	Medium intake rate; high fertility; very high available water capacity; subject to flooding most of the time; nearly level.	Nearly level -----	Nearly level.

TABLE 7.—Engineering

[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 for referring to other series

Soil series and map symbol	Suitability as a source of—		Soil features affecting—	
	Road fill and subgrade	Topsoil	Highway location	Pond reservoir areas
Knox: Kh, Kk, Km, Kn -----	Fair road fill; fair shear strength; fair subgrade; medium plasticity; medium support.	Fair: silty clay loam texture; low organic-matter content. Poor if slope is more than 15 percent.	Erodible; slope -----	Moderate permeability; slope.
Konawa: Ko, Kw -----	Fair road fill; fair shear strength; fair subgrade; medium plasticity; medium support.	Good where slope is less than 8 percent, fair where slope is 8 to 15 percent, and poor where slope is more than 15 percent.	Erodible; slope -----	Seepage potential; sand in drainageways; slope.
Ladoga: La -----	Fair road fill; fair shear strength; fair subgrade; medium support; medium plasticity.	Fair: silt loam to silty clay loam texture.	Erodible -----	Moderately slow permeability.
Marshall: Mb, Mc, Md -----	Fair road fill; fair shear strength; fair subgrade; medium support.	Fair: silt loam texture; 8 to 16 inches thick; high organic-matter content.	Erodible -----	Moderate permeability
Martin: Mn, Mr, Ms -----	Poor road fill; poor shear strength; poor subgrade; high plasticity; low support.	Poor: silty clay loam texture; less than 8 inches thick.	Difficult to establish vegetation; seepage potential; poor workability.	Slow permeability; shale within a depth of less than 40 inches in a few places; seepage potential.
Onawa: On, Oo -----	Poor road fill to a depth of 25 inches; poor shear strength; good road fill at a depth of 25 to 60 inches. Poor subgrade to a depth of 25 inches; high plasticity; low support; good subgrade at a depth of 25 to 60 inches.	Poor: less than 8 inches thick.	Subject to flooding; erodible; water table at a depth of 4 to 5 feet.	Slow permeability; moderately rapid below a depth of 25 inches; water table at a depth of 4 or 5 feet.
Oska: Os -----	Fair road fill; fair shear strength; fair subgrade; medium support.	Fair: silty clay loam texture; 8 to 16 inches thick.	Limestone within a depth of 40 inches.	Limestone within a depth of 40 inches; seepage potential; fractured limestone.
Pawnee: Pb, Pc, Pe -----	Poor road fill; poor shear strength; poor subgrade; low support; high plasticity.	Fair: clay loam texture; 8 to 16 inches thick.	Difficult to establish vegetation; poor workability; seepage potential; slow permeability.	Slow permeability; seepage potential along gravel pockets.
*Sarpy: Sa ----- For Haynie part, see Haynie series.	Good road fill if confined; good subgrade.	Poor: loamy fine sand and fine sand textures.	Subject to flooding; erodible.	Very rapid permeability; high seepage potential.
Sharpsburg: Sb, Sc -----	Fair road fill; fair shear strength; fair subgrade; medium plasticity; medium support.	Fair: silty clay loam texture; 8 to 16 inches thick.	Erodible -----	Moderately slow permeability.
*Shelby: Se, Sh, Sm, Sp, Ss For Pawnee part of Sp and Ss, see Pawnee series.	Fair road fill; fair shear strength; fair to poor subgrade; medium to low support.	Fair: loam and clay loam texture; 8 to 16 inches thick.	Difficult to establish vegetation.	Moderately slow permeability; seepage potential; gravel pockets.
Sibleyville: Sy -----	Good road fill; fair subgrade; medium support.	Fair: loam texture; 8 to 16 inches thick.	Sandstone within a depth of 40 inches.	Moderate permeability; sandstone within a depth of 40 inches; seepage in places.

interpretations—Continued

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions that appear in the first column]

Soil features affecting—Continued				
Embankments, dikes, and levees	Drainage of crops and pasture	Irrigation	Terraces and diversions	Waterways
Fair to good stability and compaction; fair shear strength; moderate shrink-swell potential; impervious.	Well drained; moderate permeability; sloping to steep.	Medium intake rate; high available water capacity; medium fertility; sloping to steep.	Irregular slopes; siltation of channels; erodible.	Slope; siltation of channels; erodible; medium fertility.
Fair to good stability and compaction; fair shear strength; moderate shrink-swell potential; impervious.	Well drained; rapid permeability in surface layer.	High intake rate of topsoil; low intake rate of subsoil; low fertility; gently sloping to steep; high available water capacity.	Low fertility; erodible; sedimentation of channels; slope.	Low fertility; erodible; siltation of channels; slope.
Fair to poor stability and compaction; fair shear strength; moderate to high shrink-swell potential; impervious.	Moderately well drained; moderately slow permeability; sloping.	Low intake rate; high available water capacity; medium fertility; sloping.	Dense, clayey subsoil; very hard when dry; construction difficult; erodible.	Clayey subsoil; medium fertility; siltation of channels.
Fair to good stability and compaction; fair shear strength; moderate shrink-swell potential; impervious.	Well drained; moderate permeability; gently sloping to moderately steep.	Medium intake rate; very high available water capacity; high fertility; gently sloping to moderately steep.	All features favorable	All features favorable.
Fair to poor stability and compaction; poor shear strength; high shrink-swell potential; impervious; subject to sliding.	Moderately well drained; slow permeability; seepage in places; gently sloping to moderately steep.	Low intake rate; moderate available water capacity; seepy in places; gently sloping to moderately steep.	Dense, clayey subsoil; very hard when dry; slope; construction difficult.	Clayey soil; seepy; slope; difficult to establish vegetation.
Fair to poor stability and compaction; poor shear strength; high shrink-swell potential; impervious; high organic-matter content.	Somewhat poorly drained; slow permeability; nearly level; water table at a depth of 4 or 5 feet; poor slope stability below a depth of 25 inches; erodible; side slopes of ditches; outlets remote.	Low intake rate; high available water capacity; runoff slow; high fertility; nearly level.	Nearly level	Nearly level.
Fair to poor stability and compaction; fair shear strength; high shrink-swell potential; impervious.	Well drained; slow permeability; gently sloping and sloping.	Low intake rate; moderate available water capacity; gently sloping and sloping.	Local rocky areas	Local rocky areas.
Fair to poor stability and compaction; poor shear strength; high shrink-swell potential; impervious.	Moderately well drained; slow permeability; seepy in places; gently sloping and sloping.	Low intake rate; high available water capacity; seepy in places; gently sloping and sloping.	Clayey subsoil; construction difficult.	Clay subsoil; difficult to establish vegetation; erodible.
Good stability; fair to good compaction; low shrink-swell potential; poor resistance to piping; erodible.	Excessively drained	High intake rate; low available water capacity; soil blowing; low fertility; nearly level to undulating.	Nearly level to undulating; high intake rate.	Nearly level to undulating; high intake rate.
Fair to good stability and compaction; fair shear strength; moderate to high shrink-swell potential; impervious.	Moderately well drained; moderately slow permeability; gently sloping and sloping.	Low intake rate; high available water capacity; high fertility; gently sloping and sloping.	All features favorable	All features favorable.
Fair to good stability and compaction; fair shear strength; moderate shrink-swell potential; impervious.	Moderately well drained; moderately slow permeability; gently sloping to moderately steep; seepy in places.	Low to medium intake rate; high available water capacity; gently sloping to moderately steep.	All features favorable	All features favorable.
Fill material limited by depth; fair to good stability and compaction; good shear strength; moderate shrink-swell potential; erodible; moderately impervious.	Well drained; moderate permeability; seepy in places; bedrock within a depth of 40 inches; sloping.	Medium intake rate; low to moderate available water capacity; bedrock at a depth of 20 to 40 inches; sloping.	Bedrock at a depth of 20 to 40 inches; medium fertility; erodible; siltation of channels.	Bedrock at a depth of 20 to 40 inches; medium fertility; erodible; difficult to establish vegetation.

TABLE 7.—Engineering

[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 for referring to other series

Soil series and map symbol	Suitability as a source of—		Soil features affecting—	
	Road fill and subgrade	Topsoil	Highway location	Pond reservoir areas
Sogn ----- Mapped only with Gosport soils.	Poor: limestone within a depth of 20 inches.	Poor: less than 8 inches thick; rockiness; slope is more than 15 percent in places.	Limestone within a depth of 20 inches; steep slope.	Fractured limestone; high seepage potential; steep slope.
*Vinland: Vs ----- For Sibleyville part, see Sibleyville series.	Good road fill and good subgrade.	Poor: loam texture; 8 to 16 inches thick; sandstone within a depth of 20 inches; difficult to reclaim.	Sandstone within a depth of 20 inches.	Moderate permeability; bedrock within a depth of 20 inches; high seepage potential; moderately steep slope.
Wabash: Wa -----	Poor road fill; poor shear strength; poor subgrade; high plasticity; low support.	Poor: silty clay texture; difficult to handle.	Subject to flooding; poor workability; slow internal drainage.	Very slow permeability
Welda: Wc, Wd -----	Fair road fill; fair shear strength; fair subgrade; medium plasticity; medium support.	Fair: silt loam and silty clay loam texture; 8 to 16 inches thick; low organic-matter content.	Erodible -----	Moderately slow permeability; sloping to moderately steep.
Zook: Zo -----	Fair road fill; fair shear strength; poor subgrade; low support; high plasticity.	Fair: silty clay loam texture.	Poor workability; subject to flooding; slow internal drainage.	Slow permeability -----

TABLE 8.—Engineering

Soil name and location	Parent material	Kansas report number S70—	Depth	Moisture-density ¹	
				Maximum dry density	Optimum moisture
			<i>Inches</i>	<i>Lb per cu. ft.</i>	<i>Percent</i>
Ladoga silt loam: 1,900 feet south and 900 feet west of northeast corner of SE ¹ / ₄ NE ¹ / ₄ sec. 25, T. 8 S., R. 21 E. Modal.	Loess -----	52-3-1	0-8	105	17
		52-3-2	18-29	98	21
		52-3-3	48-60	96	22
Marshall silt loam: 2,700 feet east and 300 feet south of northwest corner of NE ¹ / ₄ NW ¹ / ₄ sec. 17, T. 8 S., R. 22 E. Modal.	Loess -----	52-4-1	5-12	98	21
		52-4-2	19-25	94	22
		52-4-3	46-60	99	20
Pawnee clay loam: 1,300 feet west and 700 feet south of northeast corner of NW ¹ / ₄ NE ¹ / ₄ sec. 10, T. 10 S., R. 21 E. Modal.	Glacial till -----	52-1-1	0-8	105	18
		52-1-2	12-19	102	19
		52-1-3	26-36	108	18
		52-1-4	49-60	111	14
Wabash silty clay: 2,200 feet south and 1,300 feet east of center of SE ¹ / ₄ SE ¹ / ₄ sec. 25, T. 9 S., R. 21 E. Modal.	Clay alluvium -----	52-2-1	0-6	95	22
		52-2-2	6-19	93	25
		52-2-3	41-60	100	22

¹ Based on AASHO Designation: T 99-57, Method A (1).

² Mechanical analyses according to AASHO Designation: T 88-57 (1). Results by this procedure frequently may differ from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for naming textural classes of soils.

interpretations—Continued

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions that appear in the first column]

Soil features affecting—Continued				
Embankments, dikes, and levees	Drainage of crops and pasture	Irrigation	Terraces and diversions	Waterways
Fair to poor stability and compaction; fair shear strength; impervious; high shrink-swell potential; very limited fill material; rocky.	Not applicable -----	Not applicable -----	Not applicable -----	Not applicable.
Very limited fill material; fair to good stability and compaction; moderate shrink-swell potential; erodible; moderately pervious.	Somewhat excessively drained; bedrock within a depth of 20 inches; seepy in places; sloping to moderately steep.	Medium intake rate; low available water capacity; bedrock within a depth of 20 inches; sloping to moderately steep.	Not applicable; bedrock within a depth of 20 inches.	Bedrock within a depth of 20 inches; medium fertility; erodible; difficult to establish vegetation.
Fair to poor stability and compaction; poor shear strength; impervious; high shrink-swell potential.	Very poorly drained; very slow permeability; level and nearly level; ponding in places; outlets remote; poor workability.	Low intake rate; moderate available water capacity; level and nearly level.	Nearly level -----	Nearly level.
Fair to good stability and compaction; fair shear strength; impervious; moderate shrink-swell potential; erodible.	Well drained; sloping to moderately steep.	Low intake rate; high available water capacity; erodible; medium fertility; sloping to moderately steep.	Irregular slopes; erodible; siltation of channels; sloping to moderately steep.	Sloping to moderately steep; siltation of channels; erodible; clayey subsoil; difficult to establish vegetation; medium fertility.
Fair to poor stability and compaction; fair shear strength; impervious; high shrink-swell potential.	Poorly drained; slow permeability; outlets remote; nearly level.	Low intake rate; high available water capacity; nearly level.	Nearly level -----	Nearly level.

test data

Mechanical analysis ²							Liquid limit	Plasticity index	Classification	
Percentage less than 3 inches passing sieve—			Percentage smaller than—						AASHO	Unified
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm				
							<i>Percent</i>			
100	99	98	95	64	27	20	29	7	A-4(8)	ML-CL
100	99	98	95	79	50	42	54	30	A-7-6(19)	CH
-----	100	97	92	73	36	29	45	22	A-7-6(14)	CL
-----	100	99	94	69	37	28	42	15	A-7-6(10)	ML-CL
-----	100	98	93	74	40	35	47	22	A-7-6(14)	CL
-----	100	99	95	72	36	28	44	23	A-7-6(14)	CL
100	92	66	60	47	29	22	33	12	A-6(7)	CL
100	91	76	70	58	43	37	46	24	A-7-6(15)	CL
100	94	73	67	53	36	30	50	31	A-7-6(18)	CL
100	92	75	69	57	38	31	43	25	A-7-6(15)	CL
100	99	98	97	83	53	44	54	27	A-7-6(18)	CH
100	99	98	98	87	55	45	59	31	A-7-6(20)	CH
100	98	96	95	85	53	44	55	32	A-7-6(19)	CH

four-lane U.S. Highway No. 73, which intersects the Kansas Turnpike. Both counties have State-owned lakes and some privately owned lakes that have picnic areas and provide fishing. For those interested in the history of farming, the Agricultural Hall of Fame, located at the junction of U.S. Highways 24 and 73, has picnic areas, shelter houses, and a playground in the vicinity.

Limitations of the soils as camp areas, picnic areas, playgrounds, and paths and trails are noted in table 5. Limitations are expressed as slight, moderate, and severe.

Camp areas are used for tents, small camp trailers, and activities related to camping. They should be suitable for heavy foot and vehicular traffic, for they are used frequently during the camping season. The suitability of the soil for producing vegetation was not considered in table 5.

Picnic areas are rated only on soil features, such as drainage and texture of the surface layer. Other factors, however, such as lakes, trees, or beauty of the landscape, add to the desirability of a picnic area (fig. 16).

Playgrounds are baseball diamonds, football fields, and badminton courts. Generally required is a soil that is nearly level and has good drainage and a surface free of rocks. It is assumed that a thick vegetative cover can be established and maintained where needed.

Trails and paths considered are for cross-country hiking, horseback riding, and other nonintensive uses. Ratings are based on soil features only. Other factors, such as beauty of the landscape, that are important in selecting sites for trails and paths, were not considered.

Engineering⁵

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

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to 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 6, 7, and 8, which show, respectively, several estimated soil properties significant in engineering; interpretations for various engineering uses; and results of engineering laboratory tests on soil samples.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 6 and 7, and also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit can 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 in soil science that may not be familiar to engineers. The Glossary defines many terms commonly used in soil science.

Engineering classification systems

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

The Unified System is used to classify soils according to engineering uses for building material or for the support of structures other than highways (15). Soils are classified according to particle size distribution, plasticity index, liquid limit, and organic-matter content. Soils are grouped into 15 classes. There are eight classes of coarse-grained soils that are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. There is one class of highly organic soils, PT. Soils on the borderline between two classes are designated by symbols for both classes, for example CL-ML.

⁵ CHARLES W. STEWART, assistant State conservation engineer, and LARRY SAMPLE, civil engineer, Soil Conservation Service, helped prepare this part of the survey.

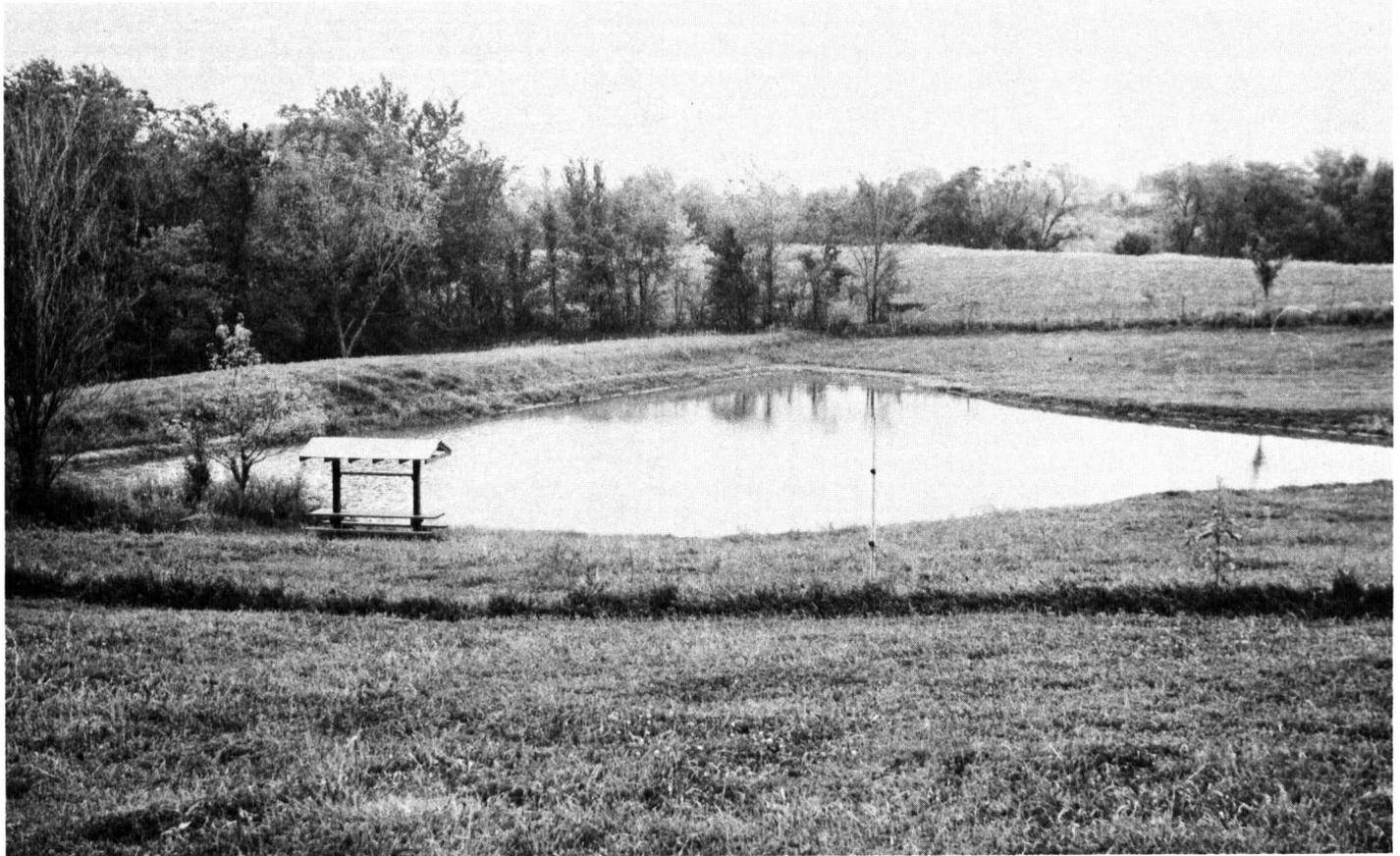


Figure 16.—Picnic area near farm pond in Shelby loam.

The AASHO system is used to classify soils according to those properties that affect their use in highway construction and maintenance (7). In this system, a soil is classified 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 which have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 8; the estimated classification, without group index numbers, is given in table 6 for all soils mapped in the survey area.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter (8). "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the "Glossary." Stones, cobblestones, and gravel are used as textural modifiers where present in the soil.

Engineering properties

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

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

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

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

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

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

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

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils can damage building foundations, roads, and other structures. Soils having a *high* shrink-swell potential are the most hazardous.

Engineering interpretations

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

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

The soils of Leavenworth and Wyandotte Counties were not rated as a source of sand and gravel. Except for Sarpy soils, only a few small areas of sand and a few pockets of gravel occur within a depth of 5 feet. Sarpy soils are a fair source of sandy material.

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

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.

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 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.

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

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among factors that are unfavorable.

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

Terraces and diversions and waterways are embankments or ridges constructed across or down the slope to intercept and carry 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 should provide outlets for runoff and not be difficult to vegetate.

Test data

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

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

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



Figure 17.—Housing development on Sharpsburg silty clay loam on the ridge. The steep soils of the Gosport-Sogn complex provide recreation areas. A central sewage system prevents pollution.

Town and Country Planning⁶

Cities and urban areas made up about 40 percent of Wyandotte County in 1965. Urban expansion has been increasing rapidly each year. The rate has been lower in Leavenworth County. In both counties, urban expansion has been greatest in areas along hard surface roads. Generally, each homesite is 1 acre or more. Business development is occurring along the major trafficways. Industrial development is mainly along valleys of Kansas and Missouri Rivers.

All of the gently sloping to moderately steep soils are suited to urban expansion if they are used within their limitations. Most of the soils have limitations that restrict their use for septic tank absorption fields, but they can be used for housing (fig. 17) and business developments if proper sewage disposal systems are installed. Many are too steep or rocky for housing developments, but they can be used for recreation, wildlife, and greenbelts.

The information in this part of the survey can be used as a basis for land use planning. It is used by land use planners, developers, bankers, agriculturalists, and interested citizens. County boards, zoning commissions, and health departments use soils infor-

mation in determining agricultural and city zoning and in implementing ordinances. Homeowners and prospective homeowners can find information about the limitations of the soils for lawns, trees, and ornamental plantings.

The soil is ordinarily examined to a depth of about 6 feet. At a greater depth, additional geological investigation may be needed. Because some delineations on the maps include soils that differ from the named soil, onsite investigation is sometimes needed.

Limitations for community development

The information in table 9 can be used by community developers and others in planning roads, building support, and sewage disposal. Important desirable features are listed. Detrimental or undesirable features are emphasized. The ratings and other information in this table are based on estimated engineering properties of the soils in table 6, on available test data in table 8, and on field experience. For information about suitability of the soil for road material, embankments, dikes and irrigation, see table 7, "Engineering Interpretations." Explanations of column headings in table 9 follow.

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

⁶ By J. D. RECTOR, assistant State resource conservationist, and LARRY D. ZAVESKY, soil scientist, Soil Conservation Service.

TABLE 9.—*Limitation of soils*

[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 for referring to other series

Soil series and map symbol	Degree and kind of limitation for—		
	Septic tank absorption fields	Sewage lagoons	Shallow excavations
Alluvial land: Aa -----	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Armster: Ac, Ad, Ae -----	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Moderate: wet; moderately well drained; fair workability; clay loam texture.
Basehor: Ba -----	Severe: bedrock within a depth of 20 inches.	Severe: moderately rapid permeability; bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.
Bremer: Br -----	Severe: slow permeability.	Slight to moderate: seasonal high water table.	Severe: wet; somewhat poorly drained; poor workability; silty clay texture.
Elmont: Ec, Ed -----	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Slight if slope is 3 to 8 percent, moderate if 8 to 12 percent.
Eudora: Eu -----	Slight if protected from flooding, moderate if subject to flooding.	Moderate: moderate permeability.	Slight if protected from flooding, moderate if subject to flooding.
*Gosport: Gc, Gs ----- For Sogn part of Gs, see Sogn series.	Severe: very slow permeability; bedrock within a depth of 40 inches.	Severe: bedrock within a depth of 40 inches.	Severe: bedrock within a depth of 40 inches.
Grundy: Gt, Gu -----	Severe: slow permeability.	Moderate: slope is 2 to 7 percent.	Severe: wet; somewhat poorly drained; poor workability; silty clay texture.
Gymer: Gy -----	Severe: moderately slow permeability.	Moderate: slope is 2 to 7 percent.	Slight -----
Haig: Hg -----	Severe: very slow permeability.	Slight -----	Severe: wet; somewhat poorly drained; poor workability; silty clay texture.
Haynie: Hy -----	Slight if protected from flooding, severe if subject to flooding.	Moderate if protected from flooding; moderate permeability. Severe if subject to flooding.	Slight if protected from flooding, moderate if subject to flooding.
Judson: Ju -----	Slight -----	Moderate: moderate permeability.	Slight -----
Kennebec: Ke -----	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Knox: Kh, Kk, Km, Kn -----	Moderate: moderate permeability. Severe if slope is more than 15 percent.	Severe: slope is more than 7 percent.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.
Konawa: Ko, Kw -----	Moderate: moderate permeability. Severe if slope is more than 15 percent.	Moderate: moderate permeability; slope is 2 to 7 percent. Severe if slope is more than 7 percent.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.
Ladoga: La -----	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent.	Moderate: wet; moderately well drained.

for community development

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions that appear in the first column]

Degree and kind of limitation for—Continued				Suitability as—
Dwellings with basements	Local roads and streets	Sanitary land fill trench	Sanitary land fill area	Sanitary land fill cover material
Severe: subject to flooding. Moderate: moderately well drained; moderate shrink-swell potential; fair bearing capacity. Severe: bedrock within a depth of 20 inches.	Severe: subject to flooding. Moderate: poor subgrade; moderate shrink-swell potential. Severe: bedrock within a depth of 20 inches.	Severe: subject to flooding. Moderate: clay loam texture. Severe: moderately rapid permeability; bedrock within a depth of 20 inches. Severe: poor workability; silty clay texture.	Severe: subject to flooding. Moderate: slope is 2 to 12 percent. Severe: moderately rapid permeability; in places slope is more than 15 percent. Moderate: wet; somewhat poorly drained.	Good. Fair: fair workability; firm clay loam subsoil; slope is 2 to 12 percent. Poor: less than 20 inches deep.
Severe: wet; somewhat poorly drained; high shrink-swell potential.	Severe: poor subgrade; high shrink-swell potential.	Moderate: fair workability; silty clay loam texture. Slight if protected from flooding, moderate if subject to flooding. Severe: bedrock within a depth of 40 inches; silty clay texture.	Slight if slope is 3 to 8 percent, moderate if 8 to 12 percent. Moderate if protected from flooding; moderate permeability. Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Poor: poor workability; very firm silty clay subsoil. Fair: fair workability; firm silty clay loam subsoil. Good.
Moderate: moderate shrink-swell potential; fair bearing capacity. Moderate: fair bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential. Severe: frost-action potential.	Severe: high shrink-swell potential.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Poor: poor workability; very firm silty clay subsoil.
Severe: wet; somewhat poorly drained; high shrink-swell potential; fair to poor bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential. Severe if slope is more than 15 percent. Severe: poor subgrade; high shrink-swell potential.	Severe: workability; silty clay texture.	Moderate: wet; somewhat poorly drained.	Poor: poor workability; very firm silty clay subsoil.
Moderate: moderate shrink-swell potential; fair bearing capacity. Severe: wet; somewhat poorly drained; workability; silty clay texture; high shrink-swell potential; poor bearing strength.	Moderate: fair subgrade; moderate shrink-swell potential. Severe: poor subgrade; high shrink-swell potential.	Moderate: workability; silty clay loam texture.	Slight -----	Fair: fair workability; firm silty clay loam subsoil. Poor: poor workability; very firm silty clay subsoil; difficult to establish vegetation.
Moderate if protected from flooding; fair bearing capacity. Severe if subject to flooding.	Severe: frost-action potential.	Severe: wet; somewhat poorly drained; workability; silty clay texture.	Moderate: wet; somewhat poorly drained.	Good.
Moderate: moderate shrink-swell potential; fair bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential; frost-action potential.	Slight if protected from flooding, severe if subject to flooding.	Moderate: subject to flooding; moderate permeability.	Good.
Severe: subject to flooding.	Severe: subject to flooding; poor subgrade; moderate shrink-swell potential; frost-action potential.	Slight -----	Slight -----	Good.
Moderate: moderate shrink-swell potential; fair bearing capacity.	Severe: subject to flooding; poor subgrade; moderate shrink-swell potential; frost-action potential.	Severe: subject to flooding.	Severe: subject to flooding.	Good.
Moderate: moderate shrink-swell potential; fair bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential. Severe if slope is more than 15 percent.	Moderate if slope is 15 to 25 percent, severe if more than 25 percent.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Fair if slope is 8 to 15 percent, poor if more than 15 percent.
Moderate: moderate shrink-swell potential; fair bearing capacity; slope is 8 to 15 percent. Severe if slope is more than 15 percent.	Moderate: fair subgrade; moderate shrink-swell potential.	Slight -----	Severe: moderately rapid permeability in surface layer.	Fair: cover material 20 to 40 inches deep. Poor if slope is more than 15 percent.
Moderate: moderate to high shrink-swell potential; fair to poor bearing capacity.	Moderate: fair subgrade; moderate to high shrink-swell potential.	Moderate: fair workability; silty clay loam texture.	Slight -----	Fair: fair workability; firm silty clay loam subsoil.

TABLE 9.—*Limitation of soils*

[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 for referring to other series

Soil series and map symbol	Degree and kind of limitation for—		
	Septic tank absorption fields	Sewage lagoons	Shallow excavations
Marshall: Mb, Mc, Md -----	Slight if slope is less than 8 percent, moderate if more than 8 percent.	Moderate: moderate permeability; slope is 2 to 7 percent. Severe if slope is more than 7 percent.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.
Martin: Mn, Mr, Ms -----	Severe: slow permeability	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Severe: poor workability; silty clay texture.
Onawa: On, Oo -----	Severe: subject to flooding.	Moderate: water table at a depth of 4 to 5 feet; moderate permeability below a depth of 25 inches.	Severe: wet; somewhat poorly drained; poor workability; silty clay texture.
Oska: Os -----	Severe: slow permeability; bedrock within a depth of 40 inches.	Severe: bedrock within a depth of 40 inches.	Severe: bedrock within a depth of 40 inches.
Pawnee: Pb, Pc, Pe -----	Severe: slow permeability	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Moderate: wet; moderately well drained; fair workability; clay loam texture.
*Sarpy: Sa ----- For Haynie part, see Haynie series.	Slight if protected from flooding, severe if subject to flooding; hazard of pollution in places.	Severe: rapid permeability.	Severe: sandy texture--
Sharpsburg: Sb, Sc -----	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Moderate: wet; moderately well drained; fair workability; silty clay loam texture.
*Shelby: Se, Sh, Sm, Sp, Ss ----- For Pawnee part of Sp and Ss, see Pawnee series.	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Moderate: wet; moderately well drained.
Sibleyville: Sy -----	Moderate to severe: permeable bedrock within a depth of 40 inches.	Severe: bedrock within a depth of 40 inches.	Moderate: rippable bedrock within a depth of 40 inches.
Sogn: ----- Mapped only with Gosport soils.	Severe: bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.
Vinland: Vs ----- For Sibleyville part, see Sibleyville series.	Severe: bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.
Wabash: Wa -----	Severe: very slow permeability; subject to flooding.	Severe: subject to flooding.	Severe: wet; very poorly drained; poor workability; silty clay texture; subject to flooding.
Welda: Wc, Wd -----	Severe: moderately slow permeability.	Moderate if slope is 2 to 7 percent, severe if more than 7 percent.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.
Zook: Zo -----	Severe: slow permeability; subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.

for community development—Continued

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions that appear in the first column]

Degree and kind of limitation for—Continued				Suitability as—
Dwellings with basements	Local roads and streets	Sanitary land fill trench	Sanitary land fill area	Sanitary land fill cover material
Moderate: moderate shrink-swell potential; fair bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential; frost-action potential.	Slight -----	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.	Good if slope is less than 8 percent, fair if more than 8 percent.
Severe: high shrink-swell potential; poor bearing capacity.	Severe: poor subgrade; high shrink-swell potential.	Severe: poor workability; silty clay texture.	Slight if slope is less than 8 percent, moderate if more than 8 percent.	Poor: poor workability; very firm silty clay subsoil; difficult to establish vegetation.
Severe: subject to flooding; wet; somewhat poorly drained.	Severe: poor subgrade; high shrink-swell potential.	Severe: poor workability; silty clay texture; subject to flooding.	Severe: subject to flooding.	Poor: poor workability; very firm silty clay subsoil.
Severe: high shrink-swell potential; bedrock within a depth of 40 inches.	Severe: fair subgrade; high shrink-swell potential.	Severe: bedrock within a depth of 40 inches.	Slight -----	Fair: fair workability; firm silty clay loam subsoil; difficult to establish vegetation.
Severe: high shrink-swell potential; fair to poor bearing capacity.	Severe: poor subgrade; high shrink-swell potential.	Moderate: fair workability; clay loam texture.	Slight -----	Fair: fair workability; firm clay loam subsoil; difficult to establish vegetation.
Slight if protected from flooding, severe if subject to flooding.	Moderate if protected from flooding, severe if subject to flooding.	Severe: sandy texture; rapid permeability.	Severe: rapid permeability.	Poor: sandy texture.
Moderate: wet; moderately well drained; moderate to high shrink-swell potential; fair to poor bearing capacity.	Moderate: fair subgrade; moderate to high shrink-swell potential.	Moderate: fair workability; silty clay loam texture.	Slight -----	Fair: fair workability; firm silty clay loam subsoil.
Moderate: wet; moderately well drained; moderate shrink-swell potential; fair bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential.	Moderate: fair workability; clay loam texture.	Slight -----	Fair: fair workability; firm clay loam subsoil.
Moderate: rippable bedrock within a depth of 40 inches; moderate shrink-swell potential.	Moderate: fair subgrade; moderate shrink-swell potential.	Severe: rippable bedrock within a depth of 40 inches.	Slight -----	Fair: less than 40 inches deep.
Severe: bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.	Moderate if slope is 8 to 15 percent, severe if more than 15 percent.	Poor: bedrock within a depth of 20 inches.
Severe: bedrock within a depth of 20 inches.	Moderate: rippable bedrock within a depth of 20 inches.	Severe: bedrock within a depth of 20 inches.	Moderate if slope is 8 to 12 percent.	Poor: bedrock within a depth of 20 inches.
Severe: subject to flooding.	Severe: subject to flooding; poor subgrade; high shrink-swell potential; wet; very poorly drained.	Severe: subject to flooding.	Severe: subject to flooding.	Poor: poor workability; very firm silty clay subsoil; wet; very poorly drained.
Moderate: moderate shrink-swell potential; fair bearing capacity.	Moderate: fair subgrade; moderate shrink-swell potential.	Moderate: fair workability; silty clay loam texture.	Slight if slope is less than 8 percent, moderate if 8 to 15 percent.	Fair: fair workability; firm silty clay loam subsoil; hazard of erosion.
Severe: subject to flooding.	Severe: wet; poorly drained; poor subgrade; high shrink-swell potential.	Severe: subject to flooding.	Severe: subject to flooding.	Fair to poor: poor workability; firm silty clay loam subsoil; difficult to establish vegetation; wet; poorly drained.

soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and increases the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

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

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

Dwellings, as rated in table 9, are no more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load, and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Local roads and streets, as rated in table 9, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep. Soil properties that most affect design and construction of roads and streets are load supporting capacity and stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, determine traffic supporting capacity. Wetness and flooding affect the stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect the ease of excavation and amount of cut and fill needed to reach an even grade.

Sanitary landfill is a method of disposing of refuse

in dug trenches or by placing refuse on the surface of the soil. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 9 apply only to a depth of about 6 feet. Ratings of *slight* or *moderate*, therefore, may not be valid if trenches are to be much deeper than 6 feet. For some soils, reliable predictions can be made to a depth of 10 or 15 feet. Nevertheless, every site should be investigated before it is selected.

The degree of limitation is expressed as *slight*, *moderate*, or *severe*. If the rating is *moderate* or *severe*, the detrimental or undesirable features are stated. If the rating is *slight*, no major limitation is anticipated and no explanation is given. The ratings are defined as follows (4).

A rating of *slight* means that the soil is free of limitations that affect the intended use, or that limitations are easy to overcome. A rating of *moderate* means that the limitation generally can be overcome by correct planning and careful design. A rating of *severe* means that careful planning and above-average design are required.

Texture, permeability, reaction, and shrink-swell potential are defined in table 6. Workability is reflected by soil properties that affect the ease of digging, moving, and spreading soil material during wet and dry periods.

Selection of shrubs and trees

Table 10 contains information that can be used in selecting shrubs and trees, by woodland suitability groups. The plants are grouped as deciduous trees, deciduous shrubs and vines, broadleaf evergreen shrubs and vines, evergreen trees, and coniferous evergreen trees and shrubs.

The shrubs and trees popular in the survey area are rated for use as shade trees and ornamentals and as habitat for wildlife. The potential height and the growth rate are shown. These plantings can also be used in screens, borders, hedges, windbreaks, and critical areas.⁷

Suitability for orchards, gardens, and lawns

Table 11 shows the suitability of the soils for orchard fruits, garden vegetables, truck crops, and lawn grasses. Among the fruits commonly grown are apples, cherries, peaches, and plums, and bush fruits and other such fruits as blackberries, currants, gooseberries, grapes, raspberries, and strawberries. Among the garden vegetables and truck crops commonly grown are cantaloup, potatoes, tomatoes, watermelons, and a variety of common vegetables. Among the lawn grasses are the "cool season" Kentucky bluegrass, Merion bluegrass, and tall fescues and the "warm season" Zoysia grass. For additional information, pamphlets and bulletins are available at the local county extension office.

⁷ PARKS, CHARLES, and QUINLIN, L. R., What Shall I Plant? Ext. Circular 292, 16 pp., illus., Extension Serv., Kansas State Univ. 1968.

TABLE 10.—*Selection of shrubs and trees, by woodland suitability groups*

[The letter "x" indicates species suitability; an asterisk indicates species most commonly grown in the survey area]

DECIDUOUS TREES

Common name	Woodland suitability group	Shade	Orna-mental	Wild-life food or cover	Potential height	Growth rate	General remarks
*Ash, green	2o1, 3w2, 4w2, 5w3	x	x	x	<i>Feet</i> 50-60	Rapid	Requires space and shade.
Ash, white	2o1, 3w2, 4w2, 5w3	x	x	x	50-70	Rapid.	
Baldcypress	2o1, 3w2, 4r2, 4w2, 5w3		x		50-70	Rapid.	
*Birch, European white	3w2, 4r2, 4w2, 5w3		x		30-40	Rapid	Irrigate.
Birch, river	2o1, 3w2, 4s2, 4w2, 5w3		x		40-60	Rapid.	
Boxelder	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	50-60	Rapid.	
Cardinal autumn-olive	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 5d2 ¹ , 5w3.		x	x	15-25	Rapid	Breaks easily.
Catalpa, northern	2o1, 3w2, 4o1, 4s2, 4w2		x		40-50	Rapid.	
Coffeetree, Kentucky	2o1, 3w2, 4o1, 4s2, 4w2, 5w3.	x		x	0-50	Rapid.	
*Cottonwood	2o1, 3w2, 4s2, 4w2, 5w3	x		x	80-100	Rapid	Plant male trees only.
Crabapple, Hopa	2o1, 3w2, 4o1, 4r2, 4s2		x	x	15-20	Moderate.	
*Dogwood, flowering	3w2, 4o1, 4r2, 4w2, 5w3		x	x	15-25	Slow	Shade preferred.
*Elm, American	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.	x			70-80	Moderate	Disease prone.
Elm, Augustine ascending	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.	x			70-80	Moderate.	
Elm, Chinese	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.	x			35-45	Rapid	Resists Dutch Elm disease.
Elm, Christine Buisman	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.	x			60-70	Moderate.	
Elm, rock	All groups	x			40-50	Moderate.	
Ginkgo	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	x	x		50-75	Moderate	Plant male trees only.
Golden raintree	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	20-40	Moderate.	
*Hackberry, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	50-70	Rapid	Drought resistant.
*Hawthorn, cock spur	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x	x	25-30	Moderate	Long thorns.
*Hawthorn, Washington	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x	x	25-30	Moderate.	
*Honey Locust, thornless	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	40-50	Rapid	Very drought resistant.
Lilac, Japanese tree	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		20-30	Moderate.	
*Linden, American	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5d2 ¹ , 5w3.	x	x		40-60	Moderate.	
Locust, black	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	35-40	Rapid	Poor tree.
Magnolia, saucer	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.		x		15-30	Moderate.	
Maple, Japanese	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.		x		8-12	Slow.	
*Maple, Norway	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.	x	x	x	40-60	Moderate.	
Maple, Schwedler	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.	x	x	x	40-50	Moderate.	
*Maple, silver	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.	x	x	x	70-80	Rapid.	
Maple, sugar	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.	x	x	x	40-70	Moderate.	
*Moraine Locust	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	x	x		40-50	Rapid.	
Oak, bur	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.	x		x	50-80	Moderate	Slow growing.
Oak, chinkapin	4o1, 4r2, 5d2	x		x	35-50	Slow	Grows on rock ridges.
*Oak pin	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 4w3.		x	x	50-60	Moderate	Well adapted to low-land.
*Oak, red	2o1, 3w2, 4o1 ¹ , 4w2, 5r2 ¹ .	x	x	x	60-80	Rapid	Fairly fast growing.
Oak, shingle	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	60-70	Moderate.	
Oak, white	2o1, 3w2, 4o1, 4r2, 4w2, 5d2 ¹ .	x	x	x	60-80	Moderate	Grows best on cool slopes.

TABLE 10.—Selection of shrubs and trees, by woodland suitability groups—Continued
 [The letter "x" indicates species suitability; an asterisk indicates species most commonly grown in the survey area]

DECIDUOUS TREES

Common name	Woodland suitability group	Shade	Orna-mental	Wild-life food or cover	Potential height	Growth rate	General remarks
Osage-orange	All groups	x		x	20-40	Moderate.	
Pagoda tree, Japanese	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.	x	x	x	50-60	Rapid.	
Peach, double flowering	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		18-20	Moderate.	
*Plane tree, American	2o1, 3w2, 4w2	x		x	70-80	Rapid.	
Plane tree, London	2o1, 3w2, 4w2	x	x	x	50-70	Rapid.	
Plum, Newport	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	0-15	Moderate.	
Plum, Pissard	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	15-20	Moderate.	
Poplar, Bolkana	2o1, 3w2, 4o1, 4r2, 4s2		x		50-60	Rapid.	
Poplar, lombardy	2o1, 3w2, 4o1, 4r2, 4s2		x		0-60	Rapid.	
Poplar, white	2o1, 3w2, 4o1, 4r2, 4s2	x	x		60-80	Rapid.	
Redbud, eastern	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	10-20	Rapid.	
Russian-olive	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	15-25	Rapid.	
Soapberry, western	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	0-20	Moderate.	
Sweetgum, American	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4w2, 5w3.	x	x		40-50	Moderate.	
Tree of Heaven	2o1, 3w2, 4o1, 4r2 ¹ , 4w2, 5w3.	x	x	x	40-50	Rapid.	
Tulip tree	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5w3.	x	x		50-70	Rapid.	
Willow, black	2o1, 3w2, 4s2, 4w2, 5w3			x	35-40	Rapid	Protects stream banks.
Yellowwood, American	2o1, 3w2, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	30-40	Moderate.	
*Walnut, black	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x	x	50-70	Rapid.	

DECIDUOUS SHRUBS AND VINES

*Almond, cherry flowering	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		3-4	Moderate.	
Amur honeysuckle	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	5-6	Rapid	Suitable for critical area plantings.
*Barberry, Japanese	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	3-5	Moderate	Suitable for hedge plantings.
*Barberry, mentor	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		3-5	Moderate	Suitable for hedge plantings.
Barberry, redleaf	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	3-4	Moderate	Suitable for hedge plantings.
*Beauty bush	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		6-8	Moderate.	
*Bittersweet, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		25-30	Fast.	
*Bittersweet, Oriental	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		25-30	Fast.	
*Bladder Senna, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		5-8	Moderate.	
*Buckhorn, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	10-14	Moderate.	
*Buffaloberry, silver	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	6-14	Moderate.	
*Butterflybush, orangeeye	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		3-8	Rapid.	
Chastetree, lilac	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		6-8	Rapid	Suitable for screen, barrier, and hedge plantings.
*Cotoneaster, Peking	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	5-7	Moderate	Suitable for screen, barrier, and hedge plantings.
*Cotoneaster, spreading	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	3-5	Moderate	Suitable for hedge plantings.
*Coralberry, Chenault	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	2-3	Moderate.	

TABLE 10.—*Selection of shrubs and trees, by woodland suitability groups—Continued*

[The letter "x" indicates species suitability; an asterisk indicates species most commonly grown in the survey area]

DECIDUOUS TREES

Common name	Woodland suitability group	Shade	Orna- mental	Wild- life food or cover	Potential height	Growth rate	General remarks
Coralberry, Indiancurrant	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	2-3	Moderate.	
Currant, golden	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	4-6	Moderate.	
*Dogwood, gray	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	6-8	Rapid.	
*Dogwood, redosier	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.	-----	x	x	6-8	Rapid.	
*Elder, American	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5w3.	-----	x	x	6-8	Moderate.	
*Euonymus, dwarf winged	3w2, 4o1, 4r2, 4w2	-----	x	x	4-5	Moderate.	
*Euonymus, eastern wahoo	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.	-----	x	x	8-10	Moderate.	
*Euonymus, European	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.	-----	x	x	8-10	Moderate.	
*Euonymus, winged	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	0-7	Moderate.	
*Forsythia, border	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	4-7	Rapid	Suitable for screen, barrier, hedge, and critical area plant- ings.
*Forsythia, greenstem	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	6-8	Rapid	Suitable for screen, hedge, and critical area plantings.
*Forsythia, showy border	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	4-7	Rapid	Suitable for screen, barrier, hedge, and critical area plant- ings.
*Forsythia, weeping	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	5-6	Rapid	Suitable for screen, hedge, and critical area plantings.
*Honeysuckle, Morrow	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	5-6	Rapid	Suitable for critical area plantings.
*Honeysuckle, Tatarian	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	6-8	Rapid	Suitable for critical area plantings.
*Honeysuckle, winter	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	6-8	Rapid	Suitable for critical area plantings.
*Hydrangea, Panick	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2.	-----	x	-----	6-8	Moderate.	
Hydrangea, Peegee	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2.	x	-----	-----	6-8	Moderate.	
*Hydrangea, snowhill	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2.	-----	x	-----	0-4	Moderate.	
*Jetbead, black	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	x	4-5	Moderate.	
Kerria, Japanese	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	4-5	Moderate.	
Lilac, Chinese	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	6-8	Moderate	Suitable for screen and hedge plant- ings.
*Lilac, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	8-12	Moderate	Suitable for screen and hedge plant- ings.
*Mockorange, big scentless	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	8-10	Moderate.	
*Mockorange, sweet	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	8-10	Moderate.	
Mockorange, Virginalis	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	6-8	Moderate.	
*Pearlbush, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	6-8	Moderate.	
*Peashrub, Siberian	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	-----	x	6-10	Rapid	Suitable for screen and hedge plant- ings.
*Privet, amur	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	-----	x	8-10	Rapid	Suitable for screen and hedge plant- ings.
*Privet, border	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	-----	x	5-7	Rapid	Suitable for hedge plantings.

TABLE 10.—*Selection of shrubs and trees, by woodland suitability groups—Continued*

[The letter "x" indicates species suitability; an asterisk indicates species most commonly grown in the survey area]

DECIDUOUS TREES

Common name	Woodland suitability group	Shade	Orna-mental	Wild-life food or cover	Potential height	Growth rate	General remarks
*Privet, European	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .			x	8-10	Rapid	Suitable for screen and hedge plantings.
*Privet, regal border	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .			x	3-5	Moderate.	Suitable for hedge plantings.
*Quince, flowering	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		5-6	Moderate	Suitable for hedge plantings.
*Quince, flowering Japanese	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		2-3	Moderate	Suitable for hedge plantings.
Roseacacia locust	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		3-4	Moderate.	
*Rose of Sharon	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		8-10	Moderate.	
*Smoketree, common	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		12-15	Rapid.	
*Snowball, common	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2 ¹ .		x		6-8	Moderate.	
*Snowball, European	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2 ¹ .		x	x	6-8	Moderate.	
Snowball, Japanese	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2 ¹ .		x		6-8	Moderate.	
Spirea, Anthony Waterer	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		1-2	Rapid.	
*Spirea, bridalwreath	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		4-5	Rapid	Suitable for hedge plantings.
*Spirea, Froebel	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		2-3	Moderate.	
Spirea, garland	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		4-5	Rapid	Suitable for hedge plantings.
*Spirea, Thunberg	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		3-4	Moderate.	
*Spirea, Vanhoutte	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		4-6	Rapid	Suitable for hedge plantings.
Sumac, flameleaf	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ , 5w3.		x		3-6	Moderate.	
Sumac, smooth	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2.		x	x	8-12	Rapid.	
Sumac, Staghorn	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2.		x		10-20	Rapid.	
Tamarisk, Odessa	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		6-12	Moderate.	
*Weigela, old fashioned	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		5-6	Rapid.	

CONIFEROUS EVERGREEN SHRUBS

Arborvitae, Berkma's	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		4-6	Moderate.	
Arborvitae, Oriental	2o1, 3w2, 4o1 ¹ , 4r2, 4s2, 4w2.		x		4-6	Moderate.	
Creeping juniper, Andorra	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x		0-1	Moderate	Suitable for critical area plantings.
Creeping juniper, Waukegan	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x		1/2-2/3	Moderate	Suitable for critical area plantings.
Pfitzer, juniper	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x		4-5	Rapid	Suitable for barrier plantings.
Pfitzer, juniper compact	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x		2-3	Moderate.	
Pine Mugho, Swiss	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5w3.		x		3-10	Moderate.	
Savin, juniper	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		4-6	Moderate.	
Savin, juniper, Tamarik	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		3-4	Moderate.	
Savin, juniper, Vonheron	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		5-6	Moderate.	
Yew, Hicks	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x	x	6-10	Moderate	Suitable for screen and hedge plantings.

TABLE 10.—*Selection of shrubs and trees, by woodland suitability groups—Continued*

[The letter "x" indicates species suitability; an asterisk indicates species most commonly grown in the survey area]

DECIDUOUS TREES							
Common name	Woodland suitability group	Shade	Orna-mental	Wild-life food or cover	Potential height	Growth rate	General remarks
Yew, Wards	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		3-5	Moderate.	
BROADLEAF EVERGREEN SHRUBS AND VINES							
*Boxwood, common	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		2-3	Slow	Suitable for hedge plantings. Suitable for critical area plantings; needs shade or partial shade.
English ivy	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		20-25	Rapid	
Eunonymus, bigleaf	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x	x	25-30	Rapid	Suitable for critical area plantings; needs shade or partial shade.
Eunonymus, common	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x	x	20-25	Rapid	
Eunonymus, purpleleaf	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x	x	10-15	Rapid	Suitable for critical area plantings.
Eunonymus, upright	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x	x	4-5	Moderate.	
*Eunonymus, spreading	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5w3.		x	x	5-6	Moderate.	Suitable for hedge plantings.
*Firethorn, scarlet	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	5-7	Moderate	
*Holly, American	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2.		x	x	15-25	Moderate	Suitable for screen plantings.
Honeysuckle, Japanese	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		12-15	Rapid	
*Mahonia, orange grape	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	3-5	Slow.	Suitable for critical area plantings.
*Perwinkle, common	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	0-1/2	Moderate	
*Viburnum, leatherleaf	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	6-12	Moderate.	Suitable for critical area plantings.
EVERGREEN TREES							
Chandler, blue juniper	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x		20-30	Slow.	
Fir, Douglas	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		50-60	Moderate.	
Fir, white	2o1, 3w2, 4o1 ¹ , 4r2 ¹ , 4s2, 4w2, 5w3.		x		30-50	Rapid.	Suitable for screen and windbreak plantings.
*Pine, Austrian	2o1, 3w2, 4o1, 4s2, 4w2, 5d2 ¹ .		x	x	40-60	Rapid	
*Pine, Scotch	2o1, 3w2, 4o1, 4s2, 4w2, 5d2 ¹ .		x	x	40-50	Rapid	Suitable for screen and windbreak plantings.
*Pine, white	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .		x	x	50-70	Rapid	
Redcedar, Camert	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 4w3.		x	x	25-35	Moderate	Suitable for screen and windbreak plantings.
Redcedar, eastern	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.		x	x	25-35	Moderate	
Redcedar, Keteleer	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.		x		15-25	Moderate.	Suitable for screen and windbreak plantings.
*Redcedar, silver	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.		x		20-30	Moderate.	
Rocky Mountain, juniper	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.		x		20-30	Moderate.	Suitable for screen and windbreak plantings.
Spruce, Alberta	2o1, 3w2, 4o1, 4r2, 4s2, 4w2, 5d2 ¹ , 5w3.		x		25-40	Slow.	

TABLE 10.—*Selection of shrubs and trees, by woodland suitability groups—Continued*
 [The letter "x" indicates species suitability; an asterisk indicates species most commonly grown in the survey area]

DECIDUOUS TREES

Common name	Woodland suitability group	Shade	Orna- mental	Wild- life food or cover	Potential height	Growth rate	General remarks
Spruce, Black Hills -----	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	30-40	Slow.	Suitable for screen and windbreak plantings.
Spruce, blue Colorado -----	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	30-40	Slow.	
*Spruce, Colorado -----	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----	40-60	Moderate	
*Spruce, Norway -----	2o1, 3w2, 4o1, 4r2 ¹ , 4s2, 4w2, 5d2 ¹ .	-----	x	-----			

¹ Selected sites on deep soils that have gentle slopes.

TABLE 11.—*Suitability of soils for fruits, vegetables, and grass*

Map sym- bol	Soil	Fruit trees	Bush fruit and others	Garden vegetables and truck crops	Lawns on—	
					Undisturbed soil	Disturbed soil
Ac	Armster loam, 3 to 8 percent slopes.	Fair to good -----	Good -----	Fair -----	Good -----	Fair.
Ad	Armster loam, 8 to 12 percent slopes.	Fair to good -----	Fair -----	Fair -----	Good -----	Poor.
Ae	Armster clay loam, 8 to 12 percent slopes, eroded.	Poor -----	-----	-----	Poor -----	Poor.
Ba	Basehor complex, 5 to 30 percent slopes.	Good -----	Good -----	Fair to good -----	Fair -----	Poor.
Br	Bremer silty clay loam -----	Fair -----	Good -----	Good ¹ -----	Good -----	Fair.
Ec	Elmont silt loam, 3 to 7 percent slopes.	Fair to good -----	Good -----	Good -----	Good -----	Fair.
Ed	Elmont silt loam, 7 to 12 percent slopes.	Poor -----	Fair -----	-----	Good to fair -----	Poor.
Eu	Eudora complex, overwash -----	Excellent -----	Excellent -----	Excellent -----	Excellent -----	Good.
Gt	Grundy silty clay loam, 1 to 3 percent slopes.	Poor -----	Fair -----	Poor -----	Good -----	Fair.
Gu	Grundy silty clay loam, 3 to 7 percent slopes.	Poor -----	Fair -----	Poor -----	Good -----	Poor.
Gy	Gymer silt loam, 3 to 7 percent slopes.	Good -----	Good -----	Good ¹ -----	Good -----	Poor.
Hg	Haig silty clay loam -----	-----	-----	Poor -----	Good -----	Poor.
Hy	Haynie silt loam -----	Good -----	Good -----	Excellent -----	Good -----	Poor.
Ju	Judson silt loam -----	Excellent -----	Excellent -----	Excellent -----	Excellent -----	Good.
Ke	Kennebec silt loam ² -----	Excellent -----	Excellent -----	Excellent -----	Excellent -----	Fair.
Kh	Knox silt loam, 7 to 12 percent slopes.	Good -----	Good -----	-----	Good -----	Poor.
Kk	Knox silt loam, 12 to 18 percent slopes.	Good -----	Good -----	-----	Fair -----	Poor.
Km	Knox silty clay loam, 7 to 12 percent slopes, eroded.	Good -----	Good -----	-----	-----	-----
Kn	Knox complex, 18 to 30 percent slopes.	Fair -----	Fair -----	-----	Fair -----	Poor.
Ko	Konawa fine sandy loam, 3 to 8 percent slopes.	Good except apple -----	Good for gooseberries and currants.	Fair to good -----	Fair to good -----	Poor.
Kw	Konawa fine sandy loam, 8 to 20 percent slopes.	Fair -----	Fair for gooseberries and currants.	-----	Fair -----	Poor.
La	Ladoga silt loam, 4 to 7 percent slopes.	Good -----	Good -----	Fair to good -----	Good -----	Fair.
Mb	Marshall silt loam, 1 to 4 percent slopes.	Good to excellent -----	Excellent -----	Excellent -----	Excellent -----	Fair to good.
Mc	Marshall silt loam, 4 to 9 percent slopes.	Good -----	Good to excellent -----	Good -----	Good -----	Fair.
Md	Marshall silt loam, 9 to 15 percent slopes.	Good -----	Good -----	-----	Good -----	Fair.

TABLE 11.—*Suitability of soils for fruits, vegetables, and grass—Continued*

Map symbol	Soil	Fruit trees	Bush fruit and others	Garden vegetables and truck crops	Lawns on—	
					Undisturbed soil	Disturbed soil
Mn	Martin silty clay loam, 4 to 7 percent slopes.	-----	-----	-----	Good -----	Poor.
Mr	Martin silty clay loam, 7 to 12 percent slopes.	-----	-----	-----	Fair to good -----	Poor.
Ms	Martin soils, 6 to 12 percent slopes, eroded.	-----	-----	-----	Fair to good -----	Poor.
On	Onawa silty clay loam -----	-----	-----	-----	Fair -----	Poor.
Oo	Onawa soils, overwash -----	Fair to good -----	Fair to good -----	Fair to good -----	Poor -----	Poor.
Os	Oska silty clay loam, 3 to 8 percent slopes.	Poor -----	Fair to good -----	Fair to good -----	Good -----	Poor.
Pb	Pawnee clay loam, 1 to 4 percent slopes.	Poor -----	Poor -----	Fair to good -----	Good -----	Poor.
Pc	Pawnee clay loam, 4 to 8 percent slopes.	Poor -----	Poor -----	Poor -----	Good -----	Poor.
Sa	Sarpy-Haynie complex -----	Good -----	Good -----	Excellent -----	Good -----	Poor.
Sb	Sharpsburg silty clay loam, 1 to 4 percent slopes.	Good -----	Good -----	Good -----	Excellent -----	Fair.
Sc	Sharpsburg silty clay loam, 4 to 8 percent slopes.	Good -----	Good -----	Good ¹ -----	Good -----	Fair.
Se	Shelby loam, 1 to 4 percent slopes.	Good -----	Good -----	Good ¹ -----	Good -----	Fair.
Sh	Shelby loam, 4 to 8 percent slopes.	Fair to good -----	Good -----	Good ¹ -----	Good -----	Fair.
Sm	Shelby loam, 8 to 12 percent slopes.	Fair to good ² -----	Good -----	Good ¹ -----	Good -----	Poor.
Sp	Shelby-Pawnee complex, 4 to 8 percent slopes:	-----	-----	-----	-----	-----
	Shelby soil -----	Fair to good -----	Good -----	Good ¹ -----	Good -----	Fair.
	Pawnee soil -----	Poor -----	Poor -----	Poor -----	Good -----	Poor.
Ss	Shelby-Pawnee complex, 4 to 8 percent slopes, eroded:	-----	-----	-----	-----	-----
	Shelby soil -----	Fair -----	Fair -----	-----	Poor -----	Poor.
	Pawnee soil -----	-----	-----	-----	Poor -----	Poor.
Sy	Sibleyville loam, 4 to 8 percent slopes.	Good -----	Good -----	Good ¹ -----	Good -----	Poor.
Vs	Vinland-Sibleyville complex, 5 to 12 percent slopes:	-----	-----	-----	-----	-----
	Vinland soil -----	-----	-----	-----	Fair to poor -----	Poor.
	Sibleyville soil -----	Fair -----	Fair to good -----	-----	Fair to good -----	Poor.
Wa	Wabash silty clay -----	-----	-----	-----	Fair to good -----	Poor.
Wc	Welda silt loam, 4 to 9 percent slopes.	Good -----	Good -----	Good ¹ -----	Good -----	Poor.
Wd	Welda silt loam, 9 to 15 percent slopes.	Poor -----	Fair -----	Good ¹ -----	Fair -----	Poor.

¹ On selected gentle slopes and ridges.

² Avoid sites subject to flooding.

Tree fruits, bush and other fruits, and garden vegetables grow best on deep, medium-textured soils that are well drained. These soils have high natural fertility and high available water capacity. If irrigated, they take water well. Such soils are rated excellent. For gardens, the topsoil should be easily tilled. The best soils for gardens are nearly level or gently sloping. Soils that have a clayey subsoil that is moderately well drained and somewhat poorly drained are rated fair or poor. Other steep or clayey soils are not rated. Cantaloup and watermelon are best suited to the more sandy Eudora, Haynie, and Sibleyville soils.

Lawns grow best on undisturbed, deep, medium-textured soils that are well drained or moderately well drained. These soils have a topsoil that is high in organic-matter content and easily tilled. Such soils are rated excellent. Disturbed soil is soil that has been excavated in digging footings and basements. It contains more clay and is low in organic-matter content. Establishing a good seedbed in disturbed soil

material is therefore difficult. Also, this material packs easily and does not take water readily. A soil, such as Sharpsburg silty clay loam, that is rated excellent for a lawn in an undisturbed condition is rated fair in a disturbed condition.

Formation and Classification of the Soils

This part of the survey tells how the factors of soil formation have affected the soils in Leavenworth and Wyandotte Counties. It also explains the system of soil classification currently used and classifies each soil series in the survey area according to that system.

Factors of Soil Formation

The characteristics of a soil at any given point are determined by (1) the physical and mineralogical

composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil formation have acted on the soil material.

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

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

Parent material

Parent material refers to the unconsolidated material from which soil forms. Rocks are weathered by such natural forces as freezing and thawing, abrasion and erosion by wind and water, and biological and chemical action. In this area, glacial action has increased the weathering process by scouring and grinding the rocks.

The nature of the parent material influences the kind of soil that forms and the rate of formation. Many chemical and physical properties of the soil are inherited from the parent material.

The parent materials in Leavenworth and Wyandotte Counties are residuum from weathered limestone, sandstone, and shale of the Upper and Middle Pennsylvanian period, loess deposits, glacial sediments, and alluvial sediments. In much of the area, the rocks are covered by loess and glacial till.

Upper and Middle Pennsylvanian.—The bedrock consists of limestone and shale of the Lower Shawnee Group in the northern half of Leavenworth County, along Stranger Creek; limestone, sand, and silty shale and sandstone of the Douglas Group in the central part of Leavenworth County and west-central part of Wyandotte County; and limestone and shale of the Kansas City Group along the Kansas and Missouri Rivers (7, 11).

Residuum from these rocks provided parent material for the Basehor, Elmton, Martin, Oska, Sibleyville, Sogn, and Vinland soils. The Basehor, Sibleyville, and Vinland soils are moderately coarse textured and formed in residuum from sandy and silty shale and sandstone. The Martin soils are fine textured and formed in residuum from clayey shale. The Oska soils and the shallow Sogn soils formed in residuum from limestone.

Glacial till.—The glacial till in Leavenworth and Wyandotte Counties is primarily of Kansas age. The till is well exposed in the western and central parts of Leavenworth County. In the eastern part of Leaven-

worth and in most of Wyandotte County, especially along the Missouri River, the till is mantled with loess and is exposed only along the lower slopes of drainageways.

The Kansas Till is deeply weathered, and carbonates generally are within 4 or 5 feet of the surface. The till is brownish and is high in content of clay. It contains varying amounts of gravel and sand-size granite, quartz, and various other rocks. Where the till is thin, it also contains local sandstone and other sedimentary rocks.

The major soils formed in till are Armster, Pawnee, and Shelby soils. Pawnee soils formed in clayey till, and Shelby and Armster soils formed in till that is less clayey and more sandy and gravelly.

Loveland Loess and Peoria Loess.—After deposition, the Kansan Till was covered by a mantle of Loess. Loveland Loess, which first covered the till, is well exposed along the Kansas River in the southwestern part of Leavenworth County. The Loveland Loess was then covered by Peoria Loess, which is more extensive, especially in Wyandotte County. Loveland Loess is reddish and is the more weathered. Peoria Loess is brownish and is more silty than Loveland Loess. Gymer and Welda soils formed in Loveland Loess. Grundy, Marshall, and Sharpsburg soils are fertile, dark-colored soils that formed in Peoria Loess. The clayey Haig soils formed in a thin mantle of Peoria Loess underlain by clayey sediments.

Recent alluvium.—Alluvium is the sediment deposited along flood plains by water from rivers and their tributaries. The sediment can range from sand to clay. The coarser sediments are nearer the present channel, and the finer sediments are away from the channel toward the upland. Sarpy soils formed in coarse-textured alluvium, and Eudora and Haynie soils formed in medium-textured alluvium. Onawa soils formed in fine-textured alluvium underlain by medium-textured alluvium, and Wabash soils formed in fine-textured alluvium in the backwater areas adjacent to the uplands. Bremer soils formed in moderately fine textured alluvium on high terraces.

Climate

Climate influences the formation of soil directly through temperature and precipitation and indirectly through its influence on the kind and amount of vegetation and organisms. Temperature and precipitation play an important role in the physical and chemical weathering of the parent material. Organisms acting on the parent material and in the soil contribute organic matter and nutrients to the soil, and their activity is governed by the climate. Chemical, physical, and biologic processes in the soil are active in the humid, warm climate in Leavenworth and Wyandotte Counties.

Percolation of water through the soil allows the formation of horizons, or layers, in the soil. Particles of clay and other minerals are carried downward from the surface layer to form a subsoil, or B horizon. The degree of soil formation depends upon the amount of water that percolates through the soil. Factors influencing the rate and amount of percolation are the amount, type, and intensity of precipitation; the hu-

midity and temperature; the relief; and the nature of soil material.

Plant and animal life

Plants, especially grasses, provide much organic matter to the soil. They also draw nutrients from the soil and parent material. After dying, the plant material is attacked by micro-organisms to form organic matter and release the nutrients, thus enriching the surface layer of the soil. A soil under grass forms a dark-colored surface layer rich in organic matter and nutrients. Plants also protect the surface layer from erosion.

Worms and other micro-organisms also influence soil formation. Worms pass large quantities of organic matter and soil through their digestive systems, thus altering it chemically and physically. Worms also incorporate organic matter and provide for drainage and aeration along their burrows.

Most soils in Leavenworth and Wyandotte Counties are believed to have formed under a cover of grasses. Their surface layer is rich in organic matter and nutrients. Some soils along drainageways in the uplands formed under a cover of deciduous trees. These soils have a grayish surface layer and a lower content of organic matter than the soils that formed under grass.

Relief

Relief, or lay of the land, influences soil formation through its effect on runoff, erosion, drainage, temperature and moisture relations, and vegetation. Runoff is rapid on sloping landscapes; thus, the amount of water percolating through the soil is reduced. Erosion is more likely on sloping soils, thus reducing the rate of the soil formation. The rate of soil formation is the most rapid on nearly level to gently sloping soils.

Slope exposure influences the plant cover and the rate of soil formation. North- and east-facing slopes are cooler and less humid than south- and west-facing slopes. The more mature soils occur on the more humid exposures.

Time

The length of time required for the formation of a soil depends on parent material, climate, vegetation and other living organisms, and relief.

Soils that form over bedrock, such as sandstone and limestone, require more time than soils that form in loess. Horizons in the Basehor soil, which formed in residuum from sandstone, are less distinct than those in the Grundy soil, which formed in loess.

Less time is required for a soil to form in a humid, warm climate. Assuming loess as the parent material, the horizons of soils in the western part of Kansas are less well defined than those in the eastern part of Kansas, mainly because rainfall is lighter and the plant cover, which is indirectly influenced by the climate, differs.

More time is required for the formation of a sloping soil because runoff is greater and less water percolates through the soil. Sharpsburg soils, which are on narrow sloping ridges, have a less clayey subsoil than Grundy soils, which are in broad, gently sloping areas.

Among some of the oldest soils in the county are Grundy, Pawnee, and Martin soils that formed in loess, till, and shale residuum, respectively. They have a well defined subsoil, or B horizon. Eudora and Haynie soils, among the younger soils, formed in recent alluvium. They lack distinct horizons.

Classification of the Soils

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

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as counties and continents.

The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study. Therefore, readers interested in development of the current system should search the latest literature available (10).⁸ In table 12, the soil series of Leavenworth and Wyandotte Counties, are placed in some categories of the current system.

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

Order.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols, and Histosols, which occur in many different kinds of climate. Table 12 shows that the four orders represented in Leavenworth and Wyandotte Counties are Alfisols, Entisols, Inceptisols, and Mollisols.

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

⁸ See the unpublished working document "Selected Chapters from the Unedited Text of the Soil Taxonomy" available in the SCS State Office, Salina, Kansas.

TABLE 12.—Soils classified according to the current system of classification

Series	Family	Subgroup	Order
Armster	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Basehor	Loamy, siliceous, mesic	Lithic Dystrachrepts	Inceptisols.
Bremer	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Elmont	Fine-silty, mixed, mesic	Typic Argiudolls	Mollisols.
Eudora	Coarse-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Gosport	Fine, illitic, mesic	Typic Dystrachrepts	Inceptisols.
Grundy	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Gymer	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Haig ¹	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Haynie	Coarse-silty, mixed (calcareous), mesic	Typic Udifluvents	Entisols.
Judson ²	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Knox	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Konawa ³	Fine-loamy, mixed, thermic	Ultic Haplustalfs	Alfisols.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Marshall	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Martin	Fine, mixed, mesic	Aquic Argiudolls	Mollisols.
Onawa	Clayey over loamy, montmorillonitic (calcareous), mesic.	Mollic Fluvaquents	Entisols.
Oska	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Pawnee	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Sharpsburg	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sibleyville	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Vinland	Loamy, mixed, mesic, shallow	Typic Hapludolls	Mollisols.
Wabash	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
Welda	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Zook	Fine, montmorillonitic, mesic	Cumulic Haplaquolls	Mollisols.

¹ The Haig soils in Leavenworth County are taxadjuncts to the Haig series because they are less acid and are slightly shallower over silty clay than is defined as the range for the series.

² The Judson soils in Leavenworth and Wyandotte Counties are taxadjuncts to the Judson series because they have a higher chroma in the A horizon than is defined as the range for the series.

³ The Konawa soils in Leavenworth County are taxadjuncts to the Konawa series because they have a slightly cooler mean annual temperature and are more moist than is defined as the range for the series.

Entisols are recently formed mineral soils. They show little or no evidence of genetic horizons and no evidence of soil mixing caused by shrinking and swelling.

Inceptisols are mineral soils that have weakly expressed genetic horizons. Their surface layer is generally lighter colored than that of Mollisols, and shows no evidence of soil mixing caused by shrinking and swelling.

Mollisols are mineral soils that have a thick, dark-colored surface horizon containing colloids dominated by bivalent cations. They show no evidence of soil mixing caused by shrinking and swelling.

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

Great Group.—Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated, or those that contain a pan that interferes with the growth of roots

or movement of water. The features considered are the self-mulching properties of clays, soil temperature, and major differences in chemical composition, mainly in calcium, magnesium, sodium, and potassium. The great group is not shown in table 12 but can be identified because it is the last word in the name of the subgroup.

Subgroup.—Each great group is divided into subgroups, one representing the central (typic) segment of the groups, 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.

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

Additional Facts About the Counties

The territory of Leavenworth County was originally part of the Delaware, Muncie, Kickapoo, and Wyandotte Indian Reservations. Within the reserva-

tion boundary were the present counties of Leavenworth and Wyandotte. Leavenworth County was organized in 1855.

Fort Leavenworth, or Cantonment Leavenworth, was established in 1827. Leavenworth, the first incorporated city in Kansas, is the county seat of Leavenworth County. The population of the county was about 32,000 in 1870 and was 47,437 in 1972.

Wyandotte was the first incorporated city in Wyandotte County. Kansas City, Kansas, was incorporated in 1872. The population was 1,582 in 1880 and was more than 168,000 in 1971. The population of Wyandotte County was 189,491 in 1972. Kansas City, Kansas, covers about 60 square miles of the 159 square miles in Wyandotte County.

The physiography, relief, and drainage of Leavenworth and Wyandotte Counties are described on the pages that follow. Information is also given about climate, water supply, farming, industry and natural resources, and transportation and markets. Statistics on farming and population are from the Census of Agriculture and Kansas State Board of Agriculture, crop and livestock report (6).

Physiography, Relief, and Drainage

The southeast corner of Wyandotte County is in the Osage Cuestas physiographic unit. The rest of Leavenworth and Wyandotte Counties is in the Glaciated Region. The main topographic features of the counties are the valleys of the Kansas and Missouri Rivers and their tributaries. The Missouri River Valley, 2 to 3 miles wide, is along the eastern and northern boundaries of the counties. The Kansas River Valley, slightly more than 1 mile wide, is along the southern boundary. The uplands adjacent to the Missouri Valley are deeply dissected loess hills where rock crops out in places. Steep slopes and breaks formed by differential erosion of limestone, shale, and sandstone are along the Kansas River and its tributaries. The divides between the rivers and their tributaries are rolling to hilly loess and till uplands.

The Kansas River and its tributaries drain the western and southern parts of Leavenworth County and the southern part of Wyandotte County. The Missouri River and its tributaries drain the eastern part of Leavenworth County and the northern and eastern parts of Wyandotte County.

The lowest points in Leavenworth County are about 770 feet above sea level on the Missouri River flood plain at Leavenworth and about 790 feet on the Kansas River flood plain at Loring. The highest point is about 1,100 feet on the uplands above the Oread escarpment. The western and northern parts of Leavenworth County are separated from the lower eastern and southern parts by a distinct limestone escarpment. The difference in elevation ranges from 100 to 180 feet.

The lowest point in Wyandotte County is about 740 feet above sea level at the junction of the Kansas and Missouri Rivers. The highest point is about 1,060 feet on the uplands in the western part of the county. This is a difference of 320 feet.

Climate⁹

Leavenworth and Wyandotte Counties are at an elevation of about 900 feet and have a typical continental climate. The climate is characterized by warm to hot summers, cold winters, moderate surface winds, maximum precipitation in the warm season, and frequent changes in the weather from day to day.

Data on climate, as recorded by the National Weather Service at Topeka, are summarized in tables 13 and 14.

The Gulf of Mexico is the principal source of moisture for the precipitation that falls in Leavenworth and Wyandotte Counties. The average yearly precipitation for the area is about 35 inches. An average of about 70 percent of the annual rainfall falls during the growing season, April through September.

Rainfall averages about 4 inches a month from May through September. It is generally heaviest in June, which averages 5.08 inches.

Winters are generally dry. Only about 10 percent of the annual precipitation falls during December, January, and February. The average for each of these months is 1.25 inches. January, the driest month, receives 1.11 inches.

Much of the precipitation in the warm season occurs as showers and thundershowers at night or early in the morning. These showers generally are of short duration. Heavy downpours occur at times and can cause severe erosion in cultivated fields.

Extended periods of below average rainfall can occur at irregular intervals. The probability of receiving significant moisture, 0.20 inch or more in a week, is greatest late in May, early in June, and early in August. The probability of significant rainfall in summer is least during the latter part of July (3).

Leavenworth and Wyandotte Counties generally have light snowfalls that average about 20 inches per year. Moderate to heavy snow occasionally occurs as late as the early part of April, but snow generally melts rapidly.

The annual range in temperature in Leavenworth and Wyandotte Counties is fairly wide because at times heat is intense in summer and occasionally arctic air surges into the area in winter. The seasonal changes are abrupt.

Table 13 shows the average daily maximum temperature, by month. It also shows the probability of occurrence of very high or very low temperatures. For example, in January in 2 years out of 10, at least 4 days will have a minimum temperature equal to or lower than -2° . At the other extreme, in 2 years out of 10 on the average, at least 4 days in July will have a maximum temperature of 99° or higher.

Average monthly and annual precipitation and probabilities for the occurrence of light and heavy monthly and yearly totals of precipitation are also given in table 13. In 1 year out of every 10, on the average, each month from November through February has precipitation totaling less than one-third inch. Similarly, precipitation for each month from May through July is more than 8 inches in 1 year out of 10.

⁹ By RICHARD W. FENWICK, assistant State soil scientist, Soil Conservation Service, Salina, Kansas.

TABLE 13.—*Temperature and precipitation data*
[Based on data recorded in Leavenworth and Wyandotte Counties]

Month	Temperature				Precipitation		
	Average daily maximum ¹	Average daily minimum ¹	Two years in 10 will have about 4 days with—		Average total ²	One year in 10 will have—	
			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
January	39.3	19.4	58	-2	1.11	0.10	2.47
February	44.0	23.1	61	7	1.31	.21	2.73
March	55.0	32.1	75	13	2.03	.44	3.86
April	66.8	43.8	82	30	3.05	1.31	5.79
May	76.3	54.1	88	40	4.58	1.71	8.10
June	85.7	63.6	94	52	5.08	1.78	8.77
July	90.7	68.1	99	58	3.94	1.20	8.29
August	89.6	66.7	98	56	4.07	.73	7.11
September	81.7	58.0	94	44	3.95	.90	7.65
October	70.9	46.6	85	33	2.57	.40	5.66
November	55.1	33.8	72	17	2.04	.32	4.40
December	42.7	24.1	61	6	1.34	.20	2.75
Year	66.5	44.5	³ 101	⁴ -8	35.07	25.39	44.72

¹ Period of record 1910-1960.

² Period of record 1897-1960.

³ Average annual highest temperature.

⁴ Average annual lowest temperature.

TABLE 14.—*Probabilities of last freezing temperatures in spring and first in fall*
[Data recorded at Leavenworth, elevation 765 feet]

Probability	Dates for given probability and temperature				
	16°F. or lower	20°F. or lower	24°F. or lower	28°F. or lower	32°F. or lower
Spring:					
1 year in 10 later than	March 26	April 3	April 10	April 19	May 2.
2 years in 10 later than	March 20	March 28	April 5	April 14	April 27.
5 years in 10 later than	March 8	March 18	March 27	April 4	April 17.
Fall:					
1 year in 10 earlier than	November 15	November 5	October 27	October 18	October 8.
2 years in 10 earlier than	November 21	November 10	October 31	October 23	October 12.
5 years in 10 earlier than	December 3	November 21	November 10	November 1	October 22.

The freeze-free period in Leavenworth and Wyandotte Counties is about 180 to 185 days in a year (2). At Leavenworth, September 25, 1912, was the earliest date in fall for a temperature of 32° and May 6, 1944, was the latest date in spring for that temperature. At Leavenworth, the average date of the last 32° freeze in spring is about April 18, and the average date of the first 32° freeze in fall is about October 22. Crops grown in the area are generally not severely damaged, but truck garden and orchard crops are likely to be damaged late in spring in some years.

Probabilities for the last freeze in spring and the first in fall are shown in table 14. Data indicate that on an average of 5 years in 10 the last freezing temperature in spring occurs after April 17 and the first freezing temperature occurs before October 22.

Some thundershowers are accompanied by heavy rain, hailstones, and strong winds. The hailstorms are generally local, do not last long, and cause damage that varies in severity. Tornadoes occur occasionally

and sometimes cause extensive damage to an area. Tornadoes are most frequent in spring and early in summer.

Surface winds are generally light to moderate in all seasons, but strong, blustery winds do occur at times, particularly late in winter and in spring.

Except for inadequate rainfall during the growing season, the climate in Leavenworth-Wyandotte Counties is generally favorable for good growth of crops. Crop growth is aided by the amount of sunshine, favorable temperatures during the growing season, and the good distribution of rainfall.

Water Supply

Water for domestic use and for livestock on farms is obtained from streams, wells, springs, and farm ponds. On farms in the uplands, most of the water for domestic use is from wells. In some areas, where limestone and shale are near the surface, wells are

not adequate. Many wells fail during extended dry periods. In some of these areas, rural water districts now provide adequate water. Farm ponds supply water for livestock, and some of the larger ponds are used for domestic use by installing a filter and treatment system. Some springs can be developed for livestock.

There is no shortage of ground water for domestic use, watering livestock, and irrigation in the valleys of the Kansas and Missouri Rivers. Wells in the deeper alluvium of the valleys are 40 to 80 feet deep and produce more than 500 gallons per minute. Wells in the alluvium of the tributary streams to the rivers generally do not produce enough water for irrigation. Some ponds are large enough to irrigate acreages of specialty crops, such as strawberries.

The cities and towns along the Kansas and Missouri Rivers have ample water resources for urban and industrial use.

Farming

Farming in Leavenworth and Wyandotte Counties is chiefly growing cash crops and raising beef, dairy cattle, hogs, and some poultry for eggs. As of 1969, 150,000 acres was cropped in Leavenworth County and 25,000 acres in Wyandotte County (14).

The main crops are corn, grain sorghum, soybeans, and small grain. Harvested in 1969 was 15,000 acres of wheat, 14,500 acres of grain sorghum, 28,700 acres of corn, 14,000 acres of alfalfa hay, 34,000 acres of hay and pasture, and 4,300 acres of corn for silage (6). Apples and peaches also are important crops. Also grown in the counties are small acreages of oats, barley, rye, Irish potatoes, and watermelons and other truck crops.

Livestock is an important source of farm income. In Leavenworth County, the income from livestock was more than from cash crops. In Wyandotte County, the income from cash crops was more than from livestock. As of January 1, 1970, the livestock on farms totaled 5,800 milk cows, 29,200 cattle, 21,000 hogs, 1,400 sheep and lambs, and 84,000 chickens (6).

Industry and Natural Resources

Adequate supplies of water from the Missouri and Kansas Rivers and adequate sources of power and excellent transportation facilities make Kansas City diversified industrially. Kansas City is one of the nation's most important auto assembly centers. It has steel mills, steel and fabrication plants, and food processing plants. It ranks high in underground cold storage, distribution of farm machinery, production of wheat flour, railroad car handling, and production of women's outer wearing apparel. Milling wheat flour, fabricating cement building blocks, and producing greeting cards are the main industries in Leavenworth. Electric power, natural gas, water, and telephone services are large utilities in the counties. General offices for the railroads, banks, insurance companies, and retail and wholesale businesses are other important business enterprises.

Water is the most important resource. Other natu-

ral resources are sand, gravel, and limestone. Most of the sand is pumped from the Kansas River and is used chiefly in making concrete and road-surfacing material. Limestone is either mined or quarried and then crushed for use in making concrete and surfacing roads. Some is used as agricultural lime.

Transportation and Markets

Leavenworth County is served by four major railroads and motor truck lines. Wyandotte County is served by 12 trunk line railroads, 75 common carrier truck lines, and 2 common carrier barge lines. Both counties are served by the municipal airport in Kansas City, Missouri, and eight scheduled airlines. Leavenworth and Wyandotte Counties are crossed by Interstate Highway No. 70 and the Kansas Turnpike, which are four-lane limited access highways. Leavenworth is connected by four-lane U. S. Highway No. 73, which intersects the Kansas Turnpike. Leavenworth County is served by U. S. Highways 24, 40, and 73 and Kansas Highways 5, 7, 16, 32, 92, and 192. Wyandotte County is served by Interstate Highways 35 and 635 in the eastern part and by U. S. Highways 24, 40, 69, 73, and 169 and Kansas Highways 5, 7, 32, and 107. Kansas City has four-lane expressways and good streets. In addition, the counties have a good system of farm-to-market roads. These roads are either hard surfaced or covered with crushed limestone.

Markets for farm products are readily available. Most of the grain that is not fed to livestock is sold to local elevators or at Atchison or Kansas City. Most of the livestock is trucked to be marketed in Kansas City and St. Joseph, Missouri. Most of the vegetables, melons, and fruits are marketed in Kansas City and nearby towns or sold from roadside stands. Most nursery stock and turf are sold locally. Milk is sold to local processing plants, and eggs are sold to bakeries and chain grocery stores.

Literature Cited

- (1) American Association of State Highway Officials. 1961. Standard specifications for highway materials and methods of sampling and testing. Ed. 8, 2 v., illus. Washington, D.C.
- (2) Bark, L. Dean. 1959. When to expect late-spring and early-fall freezes in Kansas. Kansas State Univ. of Agr. and Appl. Sci., Kansas Agr. Expt. Sta. Bul. 415, 23 pp., illus.
- (3) ———. 1963. Chances for precipitation in Kansas. Kansas State Univ. of Agr. and Appl. Sci., Kansas Agr. Expt. Sta. Bul. 461, 83 pp., illus.
- (4) Bartelli, L. J., et al. 1966. Soil survey and land use planning. Soil Sci. Soc. Amer. and Amer. Soc. of Agron., 196 pp., illus.
- (5) Broadfoot, W. M. 1960. Field guide for evaluating cottonwood sites. U.S. Forest Serv. Occas. paper 178, 6 pp., illus.
- (6) Kansas State Board of Agriculture. 1971. Farm facts. 105 pp., illus.
- (7) Moore, R. C., et al. 1951. The Kansas rock column. State Geol. Survey of Kansas Bul. 89, 132 pp.
- (8) Portland Cement Association. 1962. PCA primer. 52 pp., illus.
- (9) Schnur, L. G. 1937. Yield, stand, and volume tables for even-aged upland oak forests. U. S. Dept. Agr. Tech. Bul. 560, 88 pp., illus.
- (10) Simonson, Roy W. 1962. Soil classification in the United States. Sci. 137: 1027-1034, illus.
- (11) State Geological Survey of Kansas. 1964. Geologic map of Kansas. 1 sheet.
- (12) United States Department of Agriculture. 1951. Soil survey manual. U. S. Dept. Agr. Handbook No. 18. 503 pp., illus.

- (13) ——— 1961. Land capability classification. U. S. Dept. Agr. Handbook No. 210, 21 pp.
- (14) ——— 1969. Kansas conservation needs inventory. 191 pp., illus.
- (15) United States Department of Defense. 1968. Unified soil classification system for roads, airfields, embankments and foundations. MIL-STD-619B, 30 pp., illus.

Glossary

- Aggregate, soil.** Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.
- Alkali soil.** Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.
- Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.
- Association, soil.** A group of soils geographically associated in a characteristic repeating pattern.
- Available water capacity** (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.
- Bedding.** Plowing, grading, or otherwise elevating the surface of a flat field into a series of broad beds, or "lands," so as to leave shallow surface drains between the beds.
- Bedrock.** The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.
- Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.
- Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.
- Clay film.** A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.
- Claypan.** A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.
- Colluvium.** Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.
- Complex, soil.** A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.
- Concretions.** Grains, pellets, or nodules of various size, 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.
- Cover crop.** A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.
- Drainage class** (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.
- Excessively drained* soils are commonly very porous and rapidly permeable and have a low water-holding capacity.
- Somewhat excessively drained* soils are also very permeable and are free from mottling throughout their profile.
- Well-drained* soils are nearly free from mottling and are commonly of intermediate texture.
- Moderately well drained* soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.
- Somewhat poorly drained* soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.
- Poorly drained* soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.
- Very poorly drained* soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.
- Erosion.** The wearing away of the land surface by wind (sandblast), running water, and other geological agents.
- Flood plain.** Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.
- Glacial drift** (geology). Rock material transported by glacial ice and then deposited; also includes the assorted and unsorted materials deposited by streams flowing from glaciers.
- Glacial till** (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.
- Gravelly soil material.** From 15 to 50 percent of material by volume, consists of rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.
- Green manure** (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.
- 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 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.

Humus. The well-decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Groups of soils having similar rates of infiltration by water, even when wetted, and similar rates of water transmission within the soil. There are four such groups of soils currently recognized by the Soil Conservation Service.

Group A.—Soils having a high infiltration rate even when thoroughly wetted, consisting chiefly of deep, well-drained or excessively drained sand, gravel or both. These soils have a high rate of water transmission and a low runoff potential.

Group B.—Soils having a moderate infiltration rate when thoroughly wetted, consisting chiefly of moderately deep to deep, moderately well drained to well drained soils of moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission and a moderate runoff potential.

Group C.—Soils having a slow infiltration rate when thoroughly wetted, consisting chiefly of (1) soils with a layer that impedes downward movement of water or (2) soils with moderately fine to fine texture and slow infiltration rate. These soils have a slow rate of water transmission and a high runoff potential.

Group D.—Soils having a very slow infiltration rate when thoroughly wetted consisting chiefly of (1) clay soils with a high swelling potential; (2) soils with a high permanent water table; (3) soils with a claypan or a clay layer at or near the surface; and (4) shallow soils over nearly impervious materials. These soils have a very slow rate of water transmission and a very high runoff potential.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none*, *very slow*, *slow*, *medium*, *rapid*, and *very rapid*.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

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

Microrelief. Minor surface configurations of the land.

Minimum tillage. Limiting the amount of fieldwork on cropland to tillage that is properly timed and essential to produce a crop and prevent soil damage. Minimum tillage is performed in a variety of ways, for example, chisel planting or till planting. All systems are designed to leave a mulch of crop residue on the soil surface.

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

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

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

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Percolation. The downward movement of water through the soil.

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*.

Phase, soil. A subdivision of soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification

in the natural landscape. A soil series, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

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

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

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

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

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

Series, soil. Group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

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.

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

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

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

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

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

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

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

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

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order

of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

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

Topsoil. A presumed fertile soil or soil material, or one that

responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Weed tree. A tree of little or no value.

Wilting point (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

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. For suggestions on use and management, see "Descriptions of the Soils." Dashes show that the mapping unit is not suited to woodland and was not assigned to a woodland group. Other information is given in tables as follows:

Acreage and extent, table 1,
page 11.
Predicted yields, table 2, page 39.
Woodland, table 3, page 40.
Wildlife, table 4, page 43.

Engineering, tables 6, 7, and 8, pages
46 to 55.
Town and country planning, table 5, page 44;
table 9, page 60; table 10, page 65; and
table 11, page 70.

Map symbol	Mapping unit	Page	Capability unit	Woodland suitability group
Aa	Alluvial land-----	10	VIw-1	3w2
Ac	Armster loam, 3 to 8 percent slopes-----	12	IIIe-3	4o1
Ad	Armster loam, 8 to 12 percent slopes-----	12	IVe-3	4o1
Ae	Armster clay loam, 8 to 12 percent slopes, eroded-----	12	VIe-1	4o1
Ba	Basehor complex, 5 to 30 percent slopes-----	12	VIe-2	5d2
Br	Bremer silty clay loam-----	14	IIw-1	4w2
Ec	Elmont silt loam, 3 to 7 percent slopes-----	15	IIIe-1	---
Ed	Elmont silt loam, 7 to 12 percent slopes-----	15	IVe-1	---
Eu	Eudora complex, overwash-----	16	I-1	2o1
Gc	Gosport complex, 10 to 30 percent slopes-----	16	VIIe-1	5d2
Gs	Gosport-Sogn complex, 7 to 35 percent slopes-----	16	VIIe-1	5d2
Gt	Grundy silty clay loam, 1 to 3 percent slopes-----	18	IIe-2	---
Gu	Grundy silty clay loam, 3 to 7 percent slopes-----	18	IIIe-2	---
Gy	Gymer silt loam, 3 to 7 percent slopes-----	19	IIIe-1	---
Hg	Haig silty clay loam-----	19	IIIs-1	---
Hy	Haynie silt loam-----	20	I-1	2o1
Ju	Judson silt loam-----	20	I-1	2o1
Ke	Kennebec silt loam-----	21	IIw-2	3w2
Kh	Knox silt loam, 7 to 12 percent slopes-----	22	IVe-5	4o1
Kk	Knox silt loam, 12 to 18 percent slopes-----	22	VIe-1	4r2
Km	Knox silty clay loam, 7 to 12 percent slopes, eroded-----	22	IVe-5	4o1
Kn	Knox complex, 18 to 30 percent slopes-----	23	VIIe-1	4r2
Ko	Konawa fine sandy loam, 3 to 8 percent slopes-----	23	IIIe-4	4o1
Kw	Konawa fine sandy loam, 8 to 20 percent slopes-----	23	VIe-1	4r2
La	Ladoga silt loam, 4 to 7 percent slopes-----	24	IIIe-3	4o1
Mb	Marshall silt loam, 1 to 4 percent slopes-----	25	IIe-1	---
Mc	Marshall silt loam, 4 to 9 percent slopes-----	25	IIIe-1	---
Md	Marshall silt loam, 9 to 15 percent slopes-----	25	IVe-1	---
Mn	Martin silty clay loam, 4 to 7 percent slopes-----	26	IIIe-2	---
Mr	Martin silty clay loam, 7 to 12 percent slopes-----	26	IVe-2	---
Ms	Martin soils, 6 to 12 percent slopes, eroded-----	26	VIe-1	---
On	Onawa silty clay loam-----	27	IIw-1	4w2
Oo	Onawa soils, overwash-----	27	IIw-1	4w2
Os	Oska silty clay loam, 3 to 8 percent slopes-----	28	IIIe-5	---
Pb	Pawnee clay loam, 1 to 4 percent slopes-----	29	IIe-2	---
Pc	Pawnee clay loam, 4 to 8 percent slopes-----	29	IIIe-2	---
Pe	Pawnee clay loam, 4 to 8 percent slopes, eroded-----	29	IVe-4	---
Sa	Sarpy-Haynie complex-----	30	IIIw-2	4s2
Sb	Sharpsburg silty clay loam, 1 to 4 percent slopes-----	31	IIe-1	---
Sc	Sharpsburg silty clay loam, 4 to 8 percent slopes-----	31	IIIe-1	---
Se	Shelby loam, 1 to 4 percent slopes-----	32	IIe-1	---
Sh	Shelby loam, 4 to 8 percent slopes-----	32	IIIe-1	---
Sm	Shelby loam, 8 to 12 percent slopes-----	32	IVe-1	---
Sp	Shelby-Pawnee complex, 4 to 8 percent slopes-----	32	IIIe-1	---
Ss	Shelby-Pawnee complex, 4 to 8 percent slopes, eroded-----	32	IVe-4	---

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Page	Capability unit	Woodland suitability group
Sy	Sibleyville loam, 4 to 8 percent slopes-----	33	IVe-6	---
Vs	Vinland-Sibleyville complex, 5 to 12 percent slopes-----	34	VIe-2	---
Wa	Wabash silty clay-----	35	IIIw-1	5w3
Wc	Welda silt loam, 4 to 9 percent slopes-----	35	IIIe-3	4o1
Wd	Welda silt loam, 9 to 15 percent slopes-----	36	IVe-3	4o1
Zo	Zook silty clay loam-----	36	IIw-2	4w2

NRCS Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at <http://offices.sc.egov.usda.gov/locator/app>.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.