SOIL SURVEY OF

Richardson County, Nebraska

NOTICE – Potential Update
Soils information in this manuscript is current as of the publication date. Situations like erosion, floods, or updated mapping may have changed some content slightly on a few acres. The most current soils information is available on-line at the Nebraska NRCS web site home page, in the e-FOTG (electronic Field Office Technical Guide). The website is www.ne.nrcs.usda.gov, then click on e-FOTG. This data is also available at the NRCS Field Office serving this county.

United States Department of Agriculture
Soil Conservation Service
in cooperation with
University of Nebraska
Conservation and Survey Division

Issued November 1974

Major fieldwork for this soil survey was done in the period 1960–66. Soil names and descriptions were approved in 1967. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1971. This survey was made cooperatively by the Soil Conservation Service and the University of Nebraska, Conservation and Survey Division. It is part of the technical assistance furnished to the Richardson County Soil and Water Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability groups, and windbreak groups.

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

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

Ranchers and others can find, under "Management of the Soils for Range," general suggestions on range management.

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 "Engineering Interpretations of Soils."

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

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

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

Cover: **A landscape of Monona soils in eastern Richardson County. (Photo courtesy of Richard Hufnagle.)**

U.S. GOVERNMENT PRINTING OFFICE: 1973

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

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SOIL SURVEY OF RICHARDSON COUNTY, NEBRASKA

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SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF NEBRASKA CONSERVATION AND SURVEY DIVISION

RICHARDSON COUNTY is in the southeast corner of Nebraska (fig. 1). The county is about 30 miles from east to west and 18 miles from north to south and has a total land area of 350,720 acres, or 548 square miles. The Missouri River is its eastern boundary. Falls City, the county seat and largest town, is in the southeastern part of the county. The climate is continental and has wide seasonal and day-to-day variations. It is suitable for growing staple crops common to the region and for raising livestock.

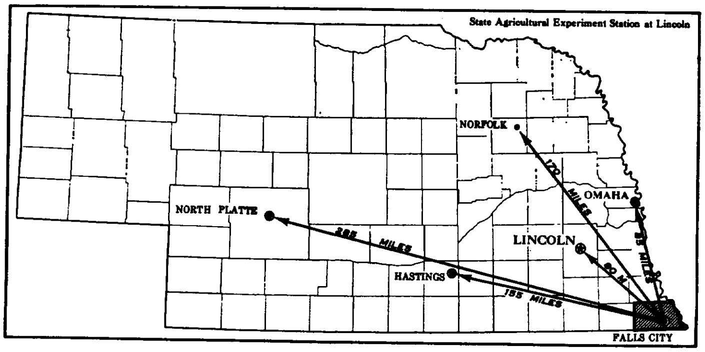

Figure 1.—Location of Richardson County in Nebraska.

Farming is the principal enterprise. In general, farming is diversified. Corn, grain sorghum, wheat, soybeans, red clover, and alfalfa are the chief crops. Less extensive crops include oats, barley, rye, sweetclover, and fruits. Wheat, soybeans, and part of the grain sorghum and corn crops generally are sold for cash, but the bulk of the field crops is used locally as feed for livestock. Small areas of native grasses and areas of bromegrass, the most common tame grass, are used for hay or pasture.

Soils in the county occur in an intricate pattern. They range from deep to shallow, from nearly level to very steep, from well drained to poorly drained, and from silt loam to clay.

[1] Part of the fieldwork was done by NORMAN L. SLAMA, LOYAL A. QUANDT, KENNETH J. GOOD, LYLE L. DAVIS, and HOWARD E. SAUTTER, Soil Conservation Service.

How This Survey Was Made

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey (*6*).[2]

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

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Sharpsburg silty clay loam, 0 to 2 percent slopes, is one of several phases within the Sharpsburg 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,

[2] Italic numbers in parentheses refer to Literature Cited, p. 70.

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. The two such kinds of mapping units shown on the soil map of Richardson County are soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Kipson-Sogn complex, 3 to 30 percent slopes.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. The name of an undifferentiated group consists of the names of the dominant soils, joined by "and." Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded, is an example.

In most areas surveyed are places where the soil material is so rocky, so shallow, 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. Gullied land is a land type in Richardson County.

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 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 Richardson County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

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

The seven soil associations in Richardson County are described in the following pages. A given soil association in this county may be identified by a different name in a recently published soil survey of an adjacent county. Such differences in name result from changes in the concepts of soil classification that have occurred since publication.

1. Haynie-Albaton association

Deep, nearly level, moderately well drained, silty soils and poorly drained, clayey soils on Missouri River bottom lands

This soil association occupies low bottom land within oxbows or bends of the Missouri River. There are three main areas. The areas are disconnected in places where the river channel reaches the adjoining bluffs of soil association 3 (fig. 2). This association is mainly nearly level. In places, floodwater deposited sediment that left the surfaces slightly undulating. Very gentle and gentle slopes occur around the few intermittent lakes and the few oxbows or swales of old stream channels. Generally, the water table is 5 to 15 feet below the surface.

This association, about 8,500 acres, makes up about 3 percent of the county. It is about 56 percent Haynie soils and 22 percent Albaton soils. Soils of minor extent make up the remaining 22 percent.

The soils formed in stratified alluvium. This alluvium contains small snail shells and disseminated lime. It is mildly or moderately alkaline.

Haynie soils are silt loams and are moderately well drained. The surface layer typically is very dark grayish-brown silt loam about 7 inches thick. The underlying material is stratified, dark grayish-brown and brown silt loam and very fine sandy loam.

Albaton soils are silty clays, are on bottom lands, and are poorly drained. Their surface layer typically is very dark gray silty clay about 5 inches thick. The underlying material is stratified, dark grayish-brown, dark-gray, and gray silty clay.

Onawa and Sarpy are less extensive soils in this association. Onawa soils are mainly in an area where the Nemaha River empties into the Missouri River. Sarpy soils are slightly undulating and sandy. They occupy

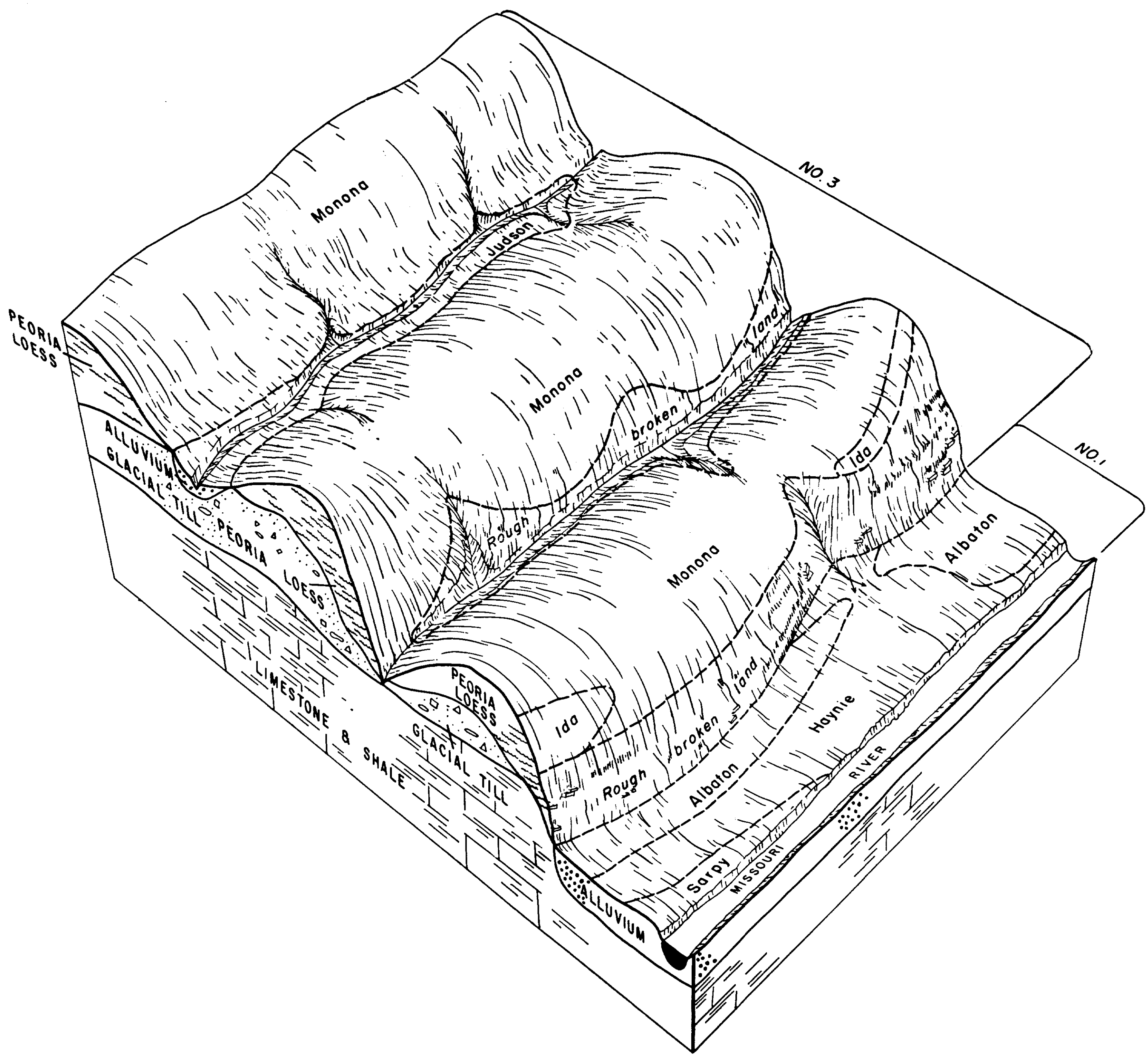

Figure 2.—**Typical pattern of soils and underlying material in associations 1 and 3.**

ridges and mounts along edges of old stream channels and near the existing channel of the Missouri River.

Nearly all of this association has been cleared of trees and is used for cultivated crops, mainly cash-grain crops, such as corn, soybeans, and grain sorghum. The main concerns of management are improving drainage and maintaining good tilth and high fertility. Occasional flooding is a hazard in places not protected by levees.

The main enterprise is growing cash crops. Farms range in size from 80 to 1,000 acres. There are few roads and farmsteads. Underground water of good quality is abundant. Water is piped to Falls City from wells southeast from the town of Rulo. The association has high potential for cultivated crops. It also has high potential for wildlife areas and recreation. It is suited to many kinds of grasses, shrubs, and trees.

2. *Kennebec-Judson-Wabash association*

Deep, nearly level to gently sloping, well-drained, silty soils and poorly drained, clayey soils on Nemaha River bottom lands and foot slopes

This soil association occupies bottom lands and foot slopes along the valleys of the Nemaha Rivers and their tributaries (fig. 3). It is mostly nearly level, very gently

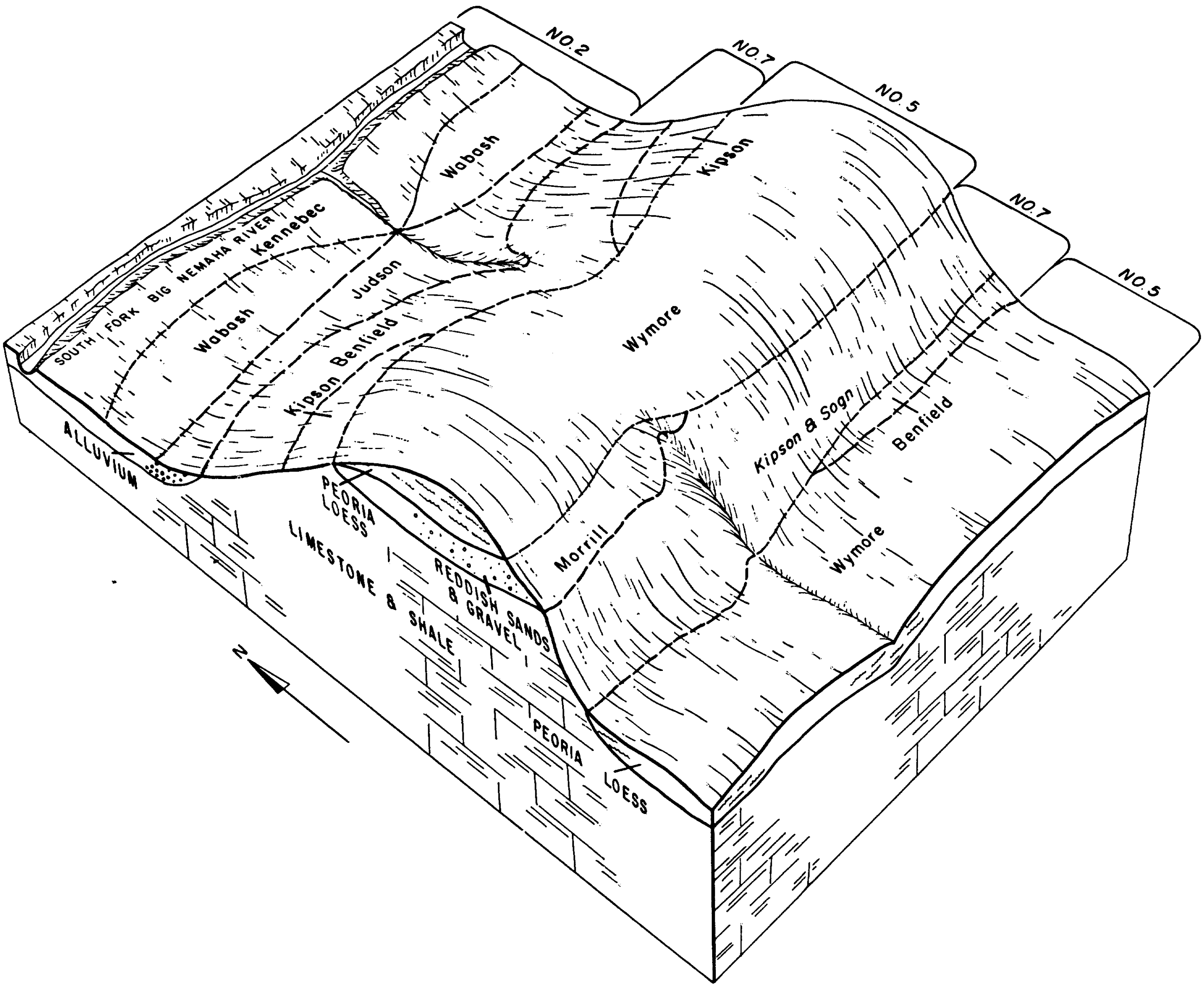

Figure 3.—Typical pattern of soils and underlying material in associations 2, 5, and 7.

sloping, and gently sloping. Steeper areas occur in a few places along streambanks and around oxbows of former stream channels. The channels of the Nemaha Rivers have been straightened from what they were originally. Levees have been built along the lower reaches of the Big Nemaha River. Generally, the water table is deep, but occasionally an area is affected by seepage.

This association, about 80,000 acres, makes up nearly 23 percent of the county. It is about 30 percent Kennebec soils, 20 percent Judson soils, and 20 percent Wabash soils. Soils of minor extent make up the remaining 30 percent.

The soils formed in alluvium. This material is neutral or slightly acid.

Kennebec soils are silt loams. They are on bottom lands, are nearly level, and are well drained. The surface layer typically is silt loam about 34 inches thick. The top 12 inches is very dark brown, the 14-inch middle layer is black, and the lowest 8 inches is very dark gray. The underlying material is very dark grayish-brown heavy silt loam or light silty clay loam in the upper part and dark-gray medium silty clay loam in the lower part.

Judson soils are silt loams. They are on foot slopes, are very gently sloping and gently sloping, and are well drained. Their surface layer typically is very dark brown heavy silt loam about 22 inches thick. The subsoil is very dark grayish-brown to dark-brown silty clay loam. Dark yellowish-brown silty clay loam is at a depth of about 45 inches.

Wabash soils on low bottom lands are nearly level and are poorly drained. The surface layer typically is very firm silty clay about 30 inches thick. The top 7 inches is very dark brown, the 8-inch middle layer is black, and the lowest 15 inches is very dark gray. The underlying material is very dark gray and dark-gray, very firm silty clay.

Less extensive in this association are Zook, Hobbs, and Nodaway soils, Silty alluvial land, and Wet alluvial land. Bottom-land areas subject to occasional overflow are occupied by Hobbs soils. Areas behind dikes are occupied by Nodaway soils. Bottom-land areas that have crooked stream channels or are frequently flooded are occupied by Silty alluvial land, and low concave areas are occupied by Wet alluvial land. Zook soils are closely intermingled with Kennebec and Wabash soils.

Nearly all of this association is used for cultivated crops. A few overflow or wet areas are used for pasture or wildlife. Cash-grain crops, such as corn, grain sorghum, soybeans, and wheat, are dominant. Some forage is grown for livestock. Improving drainage and maintaining tilth are the main concerns in management.

The main enterprise is the growing of cash crops and feed grains. Farms range in size from 80 to 640 acres. Except for main highways, not all roads on section lines pass through this association, because bridges are difficult to maintain over the straightened, deep and wide stream channels. There are only a few farmsteads. The supply of good-quality underground water is limited, but it is generally adequate for domestic use. This association has medium to high potential for cultivated crops. It is also suited to many kinds of grasses, shrubs, and trees.

3. *Monona association*

Deep, very gently sloping to steep, well-drained, silty soils on uplands

This soil association consists of a dissected, loess-capped upland plain made up of a succession of ridges, slopes, and narrow valleys. It has a rolling appearance. Except for very steep land or bluffs bordering the Missouri River Valley, slopes range from 1 to 30 percent. Very gentle slopes are in only a few places on upland divides.

This association, about 56,000 acres, makes up nearly 16 percent of the county. It is about 85 percent Monona soils. Soils of minor extent make up the remaining 15 percent.

The soils formed in uniform, windblown loess. This material is neutral, mildly alkaline, or moderately alkaline.

Monona soils are very gently sloping to steep and are well drained. The surface layer typically is very dark grayish-brown silt loam about 10 inches thick. The subsoil is dark-brown to dark yellowish-brown silt loam. Yellowish-brown silt loam is at a depth of about 34 inches.

Less extensive in this association are Rough broken land and Gullied land and Ida and Judson soils. Wooded areas of very steep slopes or bluffs that border the Missouri River Valley are occupied by Rough broken land. Eroded areas on moderately steep and steep knolls are occupied by the Ida soils. A few foot slopes or narrow valleys are occupied by Judson soils, and gullied areas along drains are occupied by Gullied land.

About 80 percent of this association is used for cultivated crops. Some of the steeper areas are cultivated, but the steepest areas are used mostly for pasture or wildlife. Corn and clover are the main crops, but grain sorghum, soybeans, wheat, and alfalfa are also grown. The main concern of management is controlling runoff, erosion, and sedimentation. Maintaining vigor in plants used for permanent cover on the steeper soils is also a concern.

Growing cash crops and raising livestock are the main enterprises in this association. Most farms range from 160 to 520 acres in size. Roads are on section lines, except in the very steep areas where there are few roads. The supply of quality well water is limited in some places, but it is generally adequate for domestic use. The very gently sloping to strongly sloping soils have a high potential for all cultivated crops commonly grown in the county. The steeper soils that border the bottom land of the Missouri River have a high potential for wildlife and are scenic.

4. *Marshall-Sharpsburg association*

Deep, nearly level to strongly sloping, well drained and moderately well drained, silty soils on uplands

This soil association consists of a dissected upland loess plain made up of divides, ridges, slopes, and narrow valleys. Gently sloping ridgetops and smooth sloping hillsides are dominant (fig. 4). Slopes are nearly level on some upland divides and are strongly sloping on a few valley sides.

This association, about 71,000 acres, makes up nearly 20 percent of the county. It is about 58 percent Marshall soils and about 38 percent Sharpsburg soils. Soils of minor extent make up the remaining 4 percent.

The soils formed in uniform, windblown loess. The material is neutral or slightly acid.

Marshall soils are nearly level to strongly sloping and are well drained. The surface layer typically is very dark brown light silty clay loam about 12 inches thick. The subsoil is dark-brown to brown and dark yellowish-brown silty clay loam. Yellowish-brown, light silty clay loam is at a depth of about 55 inches.

Sharpsburg soils are nearly level to strongly sloping and are moderately well drained. The surface layer typically is very dark brown silty clay loam about 10 inches thick. The subsoil is dark yellowish-brown and brown heavy silty clay loam in the upper and middle parts and yellowish-brown, medium silty clay loam in the lower part. Light yellowish-brown, light silty clay loam is at a depth of about 40 inches.

Judson and Geary are less extensive soils in this association. Foot slopes and narrow valleys are occupied by the Judson soils. Areas of the sloping Geary soils are closely intermingled with the major areas of Marshall and Sharpsburg soils.

Nearly all of this association is used for cultivated crops. Corn, clover, and grain sorghum are the principal crops, but soybeans, wheat, and alfalfa are also grown. Some forage sorghum and bromegrass are grown for cattle. The main concern of management is controlling runoff, erosion, and sedimentation.

Growing cash crops and raising livestock are the main enterprises in this association. Most farms range from 200 to 529 acres in size. Roads are on nearly all section lines, and farmsteads occur intermittently throughout this association. Well water is generally adequate for households. This association is expected to remain a farming area. The soils have a high potential for all cultivated crops commonly grown in the county.

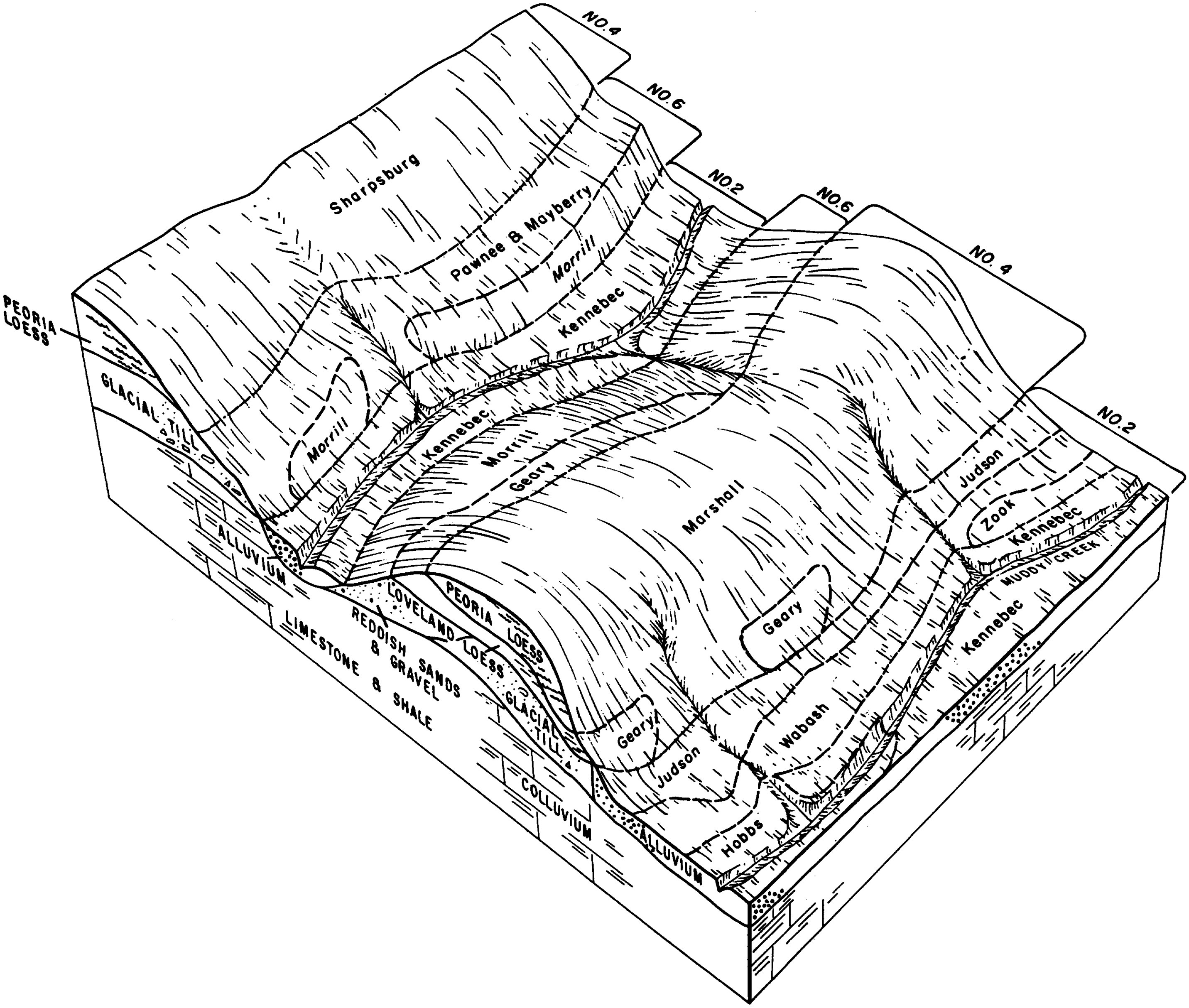

***Figure 4.*—Typical pattern of soils in associations 2, 4, and 6.**

5. *Wymore association*

Deep, nearly level to strongly sloping, moderately well drained soils that have a silty surface layer and a clayey subsoil; on uplands

This soil association consists of a loess-mantled upland plain made up of divides, benches, and ridgetops. The area is mostly gently sloping. Slopes are nearly level on the divides and benches. In a few places, they are strongly sloping on valley sides. Part of this association occurs at the highest elevations, and part of it occurs on lower valley areas downslope from association 7 (see figure 3).

This association, about 74,000 acres, makes up about 21 percent of the county. It is about 95 percent Wymore soils. Soils of minor extent make up the remaining 5 percent.

Wymore soils formed in neutral, uniform, windblown loess. They are moderately well drained. The loess mantle ranges from 3 to 15 feet in thickness. The surface layer typically is very dark brown silty clay loam about 14 inches thick. Except for the dark grayish-brown heavy silty clay loam in the lower part, the main parts of the subsoil are very dark grayish-brown to dark grayish-brown and olive-brown silty clay. Grayish-brown, mottled silty clay loam is at a depth of about 45 inches.

Sharpsburg, Judson, Benfield, and Kipson are soils of minor extent. Foot slopes and narrow valleys near drains are occupied by the Judson soils. Areas of Sharpsburg, Benfield, and Kipson soils are closely intermingled with the major areas of the Wymore soils.

About 75 percent of this association is used for cultivated crops. Grain sorghum, wheat, and clover are the principal crops, but corn, soybeans, forage sorghum, and alfalfa are also grown. Grain sorghum is grown more than corn, because the soils release moisture slowly to plants on hot, dry days. Tame bromegrass is the main grass used for pasture. Concerns of management are controlling runoff and erosion and selecting crops that are best adapted to the soil and climate.

Growing cash crops and feed crops and raising livestock are the main enterprises in this soil association. Most farms range from 200 to more than 520 acres in size. In places, farm units have acreages in adjoining associations 6 and 7. Roads are on most section lines. Well water is not available in all areas, but it is adequate in most places for domestic use. In places, farm ponds are used to store water for livestock. Areas of this association are expected to remain important to farming. The soils have a high potential for cultivated crops.

6. *Morrill-Pawnee-Mayberry association*

Deep, gently sloping to moderately steep, well drained and moderately well drained, loamy soils that have a loamy or clayey subsoil; on uplands

This soil association consists of a dissected glacial plain made up of slopes, ridgetops, and small drainageways. Areas are narrow, irregularly shaped strips that border valleys of major streams. Sloping valley sides are dominant (fig. 4). In a few places there are gently sloping ridgetops and moderately steep hillsides.

This association, about 31,000 acres, makes up nearly 9 percent of the county. It is about 38 percent Morrill soils, 23 percent Pawnee soils, and 15 percent Mayberry soils. Soils of minor extent make up the remaining 24 percent.

The soils formed in glacial deposits that contain various amounts of grit and clay. The deposits are slightly acid, neutral, or mildly alkaline.

Morrill soils are sloping to moderately steep and are well drained. The surface layer typically is very dark grayish-brown clay loam about 6 inches thick. The subsoil is dark reddish-brown to reddish-brown clay loam that in places has a gritty feel. Yellowish-red, slightly acid coarse loam is at a depth of about 45 inches.

Pawnee soils are gently sloping to strongly sloping and are moderately well drained. The surface layer typically is very dark brown clay loam about 7 inches thick. The upper 4 inches of the subsoil is very dark grayish-brown clay loam. The lower 26 inches is brown to light olive-brown clay. Light olive-brown, mildly alkaline heavy clay loam is at a depth of about 37 inches.

Mayberry soils are gently sloping to strongly sloping and are moderately well drained. The surface layer typically is very dark brown clay loam about 8 inches thick. The upper 10 inches of the subsoil is very dark grayish-brown and dark reddish-brown clay loam that has been mixed by worms and rodents. Below this is a layer of mottled dark-brown and yellowish-red clay 28 inches thick. The lower 8 inches of the subsoil is stratified, mottled brown and yellowish-red clay and sandy clay. At a depth of about 54 inches is stratified, mottled reddish-brown. brown, strong-brown, light brownish-gray, and light olive-gray sandy loam, silty clay loam, and clay.

Geary, Wymore, Sharpsburg, and Judson are the less extensive soils in this association. All of these except the Judson soils are closely intermingled with areas of the major soils. Foot slopes and narrow valleys near small drainageways are occupied by Judson soils. Geary soils are mainly in the eastern part of the association where the loess mantle is deep.

About 60 percent of this association is used for cultivated crops. Grain sorghum, wheat, and clover are the principal crops. Corn, forage sorghum, and alfalfa also are grown as cash crops and as feed for livestock. Cool-season bromegrass and some native, warm-season grasses are grown for pasture or hay. The main concerns of management are controlling erosion and maintaining tilth.

Raising livestock is the main enterprise in this soil association. Most farms are of the grain-livestock type and range from 160 to 600 acres in size. Some of the farms include areas of the adjoining associations. Roads follow most section lines. A good supply of quality well water is not available in all places, but it is generally adequate for household use. Some farmers use small dams for controlling erosion and storing water for livestock. This soil association has medium potential for cultivated crops but has high potential for grasses and for ranches where part of the acreage is used for cultivated crops.

7. *Kipson-Benfield-Sogn association*

Shallow, somewhat excessively drained, and moderately deep, well-drained, gently sloping to steep, silty soils over shale and limestone; on uplands

This soil association consists of a thoroughly dissected upland plain made up of unique bedrock highs and strips of sloping soils along the valley sides of major streams (see figure 3). Most areas occur intermittently with areas of associations 5 and 6. Slopes are mostly moderately steep and steep. They are less steep on some of the lower sides and on the few ridgetops.

This association, about 28,000 acres, makes up nearly 8 percent of the county. It is about 50 percent Kipson soils, about 30 percent Benfield soils, and about 15 percent Sogn soils. Soils of minor extent make up the remaining 5 percent.

The soils formed in limestone and moderately alkaline shales. The bedrock material is generally interbedded.

Kipson soils are shallow over shale, gently sloping to steep, and somewhat excessively drained. The surface layer typically is very dark brown light silty clay loam about 12 inches thick that contains limestone fragments. The underlying material is grayish-brown light silty clay loam that contains limestone fragments. The bedrock substratum, at a depth of about 20 inches, is light-gray silt loam and olive-gray clayey shale.

Benfield soils are moderately deep, gently sloping to moderately steep, and well drained. The surface layer typically is dark-brown silty clay loam about 7 inches thick. The subsoil is dark-brown silty clay loam in the upper part, reddish-brown silty clay in the middle part, and mixed reddish-brown and grayish-brown silty clay and silty clay loam in the lower part. Olive-gray, alkaline silty clay loam and clayey shale are at a depth of about 40 inches.

Sogn soils are shallow over limestone, gently sloping to steep, and somewhat excessively drained. The surface layer typically is very dark brown silty clay loam about 8 inches thick. It contains limestone fragments. Level-bedded limestone, loosely to firmly fixed, occurs below this surface layer.

Morrill, Wymore, and Judson are the soils of minor extent. The Morrill and Wymore soils are closely intermingled with areas of the major soils, but generally occur at the highest and the lowest elevations in the association. Foot slopes and the narrow valleys of small drainageways are occupied by the Judson soils.

Most of this association is grassland, but some areas have been invaded by shrubs, Osage-orange hedge, and locust trees. A few oak, elm, walnut, and hickory trees are along drainageways and on lower slopes adjacent to valleys. Some of the Benfield soils are cultivated. The main concerns of management are conserving moisture, controlling erosion, and maintaining a desirable permanent plant cover.

Raising cattle is the main enterprise in this soil association. Livestock farms and feed grain and livestock farms range from 160 to more than 640 acres in size. Several farms have acreages of the adjoining associations. There are few roads and farmsteads. In places, well water is not available, but springs, streams, and ponds are used for stockwater. This association has medium to high potential for grasses and ranches. It has high potential for wildlife and scenic views.

Descriptions of the Soils

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

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

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Gullied land and Rough broken land, for example, do not belong to a soil series; nevertheless, they are listed in alphabetical 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, range site, and windbreak group in which the mapping unit has been placed. The page for the description of each capability unit can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*6*).

A given soil series in this county may be identified by a different name in a recently published soil survey of an adjacent county. Such differences in name result from changes in the concepts of soil classification that have occurred since publication. The characteristics of the soil series described in this county are considered to be within the range defined for that series. In those instances where a soil series has one or more features outside the defined range, the differences are explained.

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

Soil	Area	Extent
	Acres	*Percent*
Albaton silty clay	1, 551	0. 5
Benfield silty clay loam, 3 to 9 percent slopes, eroded	5, 640	1. 6
Benfield-Kipson silty clay loams, 3 to 9 percent slopes, severely eroded	2, 106	. 6
Geary silty clay loam, 5 to 12 percent slopes, eroded	1, 409	. 4
Geary silty clay loam, 5 to 12 percent slopes, severely eroded	2, 604	. 7
Gullied land	2, 221	. 6
Haynie silt loam	3, 645	1. 0
Haynie and Albaton soils	598	. 2
Haynie and Sarpy soils	1, 190	. 3
Hobbs silt loam	7, 386	2. 1
Ida silt loam, 12 to 17 percent slopes, eroded	692	. 2
Ida silt loam, 17 to 30 percent slopes, eroded	370	. 1
Judson silt loam, 1 to 4 percent slopes	17, 423	5. 0
Kennebec silt loam	23, 919	6. 8
Kipson-Benfield silty clay loams, 9 to 17 percent slopes	7, 007	2. 0
Kipson-Sogn complex, 3 to 30 percent slopes	12, 718	3. 6
Marshall silty clay loam, 0 to 2 percent slopes	2, 317	. 7
Marshall silty clay loam, 2 to 5 percent slopes	12, 965	3. 7
Marshall silty clay loam, 5 to 12 percent slopes, eroded	19, 649	5. 6
Marshall silty clay loam, 5 to 12 percent slopes, severely eroded	7, 980	2. 2
Monona silt loam, 1 to 5 percent slopes	8, 627	2. 5
Monona silt loam, 5 to 12 percent slopes	13, 918	4. 0
Monona silt loam, 5 to 12 percent slopes, eroded	12, 923	3. 7
Monona silt loam, 12 to 17 percent slopes	1, 792	. 5
Monona silt loam, 12 to 17 percent slopes, eroded	7, 559	2. 1
Monona silt loam, 17 to 30 percent slopes	7, 802	2. 2
Morrill soils, 5 to 12 percent slopes, eroded	7, 997	2. 3
Morrill soils, 5 to 12 percent slopes, severely eroded	2, 666	. 8
Morrill soils, 12 to 17 percent slopes	1, 120	. 3
Nodaway silt loam	3, 020	. 9
Onawa silty clay	1, 271	. 4
Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded	6, 660	1. 9
Pawnee and Mayberry clay loams, 9 to 12 percent slopes, eroded	1, 753	. 5

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

Soil	Area	Extent
	Acres	*Percent*
Pawnee and Mayberry clay loams, 3 to 12 percent slopes, severely eroded	3, 294	0. 9
Rough broken land	4, 480	1. 3
Sarpy loamy fine sand	333	. 1
Sharpsburg silty clay loam, 0 to 2 percent slopes	3, 216	. 9
Sharpsburg silty clay loam, 2 to 5 percent slopes, eroded	6, 366	1. 8
Sharpsburg silty clay loam, 5 to 12 percent slopes, eroded	15, 762	4. 5
Sharpsburg silty clay loam, 3 to 12 percent slopes, severely eroded	3, 467	1. 0
Silty alluvial land	587	. 2
Slickspots-Wabash complex	664	. 8
Wabash silty clay loam	9, 939	2. 2
Wabash silty clay	6, 380	1. 8
Wet alluvial land	754	. 2
Wymore silty clay loam, 0 to 1 percent slopes	1, 164	. 3
Wymore silty clay loam, 1 to 3 percent slopes	11, 798	3. 4
Wymore silty clay loam, 3 to 9 percent slopes	7, 760	2. 2
Wymore silty clay loam, 3 to 9 percent slopes, eroded	48, 069	13. 7
Wymore silty clay loam, 9 to 12 percent slopes, eroded	771	. 2
Wymore silty clay loam, 3 to 12 percent slopes, severely eroded	3, 443	1. 0
Zook silty clay loam	11, 150	3. 2
Pits and quarries	581	. 2
Lakes and intermittent lakes (over 2 and under 40 acres)	244	. 1
Total land area	350, 720	100. 0
Water areas over 40 acres in size	2, 240	

Albaton Series

The Albaton series consists of deep, poorly drained, nearly level soils that formed in clayey alluvium. These soils are on the bottom land of the Missouri River.

In a typical profile, the surface layer is very dark gray silty clay about 5 inches thick. Below this is a transitional layer of dark-gray, very firm light silty clay. The underlying material is stratified, dark grayish-brown, dark-gray, and gray, very firm silty clay. Strong-brown mottles are common and distinct.

Albaton soils are poorly drained because they have slow runoff and slow permeability. They are moderate in available water capacity. They are mildly alkaline to moderately alkaline throughout the profile and are high in natural fertility. Tilth and wetness are concerns in management.

Most of the acreage is cultivated. Some areas are used for grassland, and some for wildlife. Some areas that have not been cleared for farming have a dense to sparse cover for young trees and an understory of grasses.

Typical profile of Albaton silty clay, in a cultivated field, 1,320 feet south and 1,320 feet west of the northeast corner of sec. 26, T. 1 N., R. 18 E.:

Ap—0 to 5 inches, very dark gray (10YR 3/1) silty clay, gray (10YR 5/1) when dry; moderate, medium, subangular blocky structure parting to weak, coarse, granular; very firm when moist, very hard when dry; calcareous; mildly alkaline; abrupt, smooth boundary.

AC—5 to 13 inches, dark-gray (10YR 4/1) light silty clay, gray (10YR 5/1) when dry; moderate, coarse and medium, blocky structure; very firm when moist, very hard when dry; common, distinct, strong-brown mottles; calcareous; mildly alkaline; gradual, smooth boundary.

Cg—13 to 50 inches, stratified, dark grayish-brown (2.5Y 4/2), dark-gray (10YR 4/1), and gray (10YR 5/1) silty clay, gray (2.5Y 6/1) when dry; moderate, coarse, blocky and coarse platy structure parting to strong, fine, angular blocky; very firm when moist, very hard when dry; common, distinct, strong-brown mottles; common, very thin, gray silt loam strata; calcareous; mildly alkaline.

The Ap horizon ranges from 4 to 9 inches in thickness, from silty clay loam to silty clay in texture, and from very dark gray to dark grayish brown in color. In some places the A horizon is absent, but in other places it is as much as 10 inches thick. The Cg horizon ranges from 27 to more than 50 inches in thickness. In places, strata of loam and fine sandy loam occur below a depth of 40 inches.

Albaton soils are in the same general areas as the Haynie and Onawa soils. They have more clay throughout the profile than Haynie soils, and the clay extends to a greater depth than in Onawa soils. Albaton soils are similar in texture to Wabash soils, which are on the bottom land of the Nemaha River, but they are not so dark colored, and they have more lime in the profile.

Albaton silty clay (0 to 1 percent slopes) (Ak).—This soil is on the Missouri River bottom land. It is subject to occasional overflow in places not protected by levees. Included in mapping were small tracts of Onawa silty clay and Haynie silt loam.

Tilth and wetness are limitations because of the clayey texture, slow permeability, and slow runoff. The soil dries slowly in spring and stays wet during periods of heavy rainfall. When dry, it becomes very hard and is difficult to work into a good seedbed.

Late-planted crops, such as grain sorghum, soybeans, wheat, alfalfa, and red clover, are best suited. Corn can be grown if the drainage is adequate and the weather is favorable. This soil is also suited to hay, pasture, and wildlife. Capability unit IIIw-1; Clayey Overflow range site; Moderately Wet windbreak group.

Benfield Series

The Benfield series consists of moderately deep, well-drained, gently sloping to moderately steep soils that formed in material weathered from clayey shales. These soils occupy the ridgetops on uplands and hillsides adjacent to some major valleys in the county.

In a typical profile, the surface layer is dark-brown silty clay loam about 7 inches thick. The subsoil is about 33 inches thick. The upper 9 inches is dark-brown, firm silty clay loam; the next 11 inches is reddish-brown, very firm silty clay; and the lower 13 inches is a mixture of reddish-brown and grayish-brown, firm silty clay and silty clay loam. The underlying material consists of olive-gray silty clay loam and clayey shale bedrock.

Benfield soils have slow permeability and moderate available water capacity. They are neutral or slightly acid in the upper part of the profile and are mildly alkaline or moderately alkaline in the lower part. They are medium to high in natural fertility but are susceptible to erosion.

Some of the acreage is cultivated and some is in pasture or range.

Typical profile of Benfield silty clay loam, 3 to 9 percent slopes, eroded, in a cultivated field, 75 feet west of the center of sec. 25, T. 1 N., R. 13 E.:

Ap—0 to 7 inches, dark-brown (7.5YR 3/2) silty clay loam, brown (7.5YR 4/2) when dry; weak, coarse, blocky structure parting to weak, medium and fine, ganular; friable when moist, hard when dry; slightly acid; abrupt, smooth boundary.

B1—7 to 16 inches, dark brown (7.5YR 3/2) heavy silty clay loam, brown (7.5YR 4/2) when dry; moderate, medium and fine, subangular blocky structure; firm when moist, very hard when dry; many dark organic coatings on faces of peds; slightly acid; gradual, smooth boundary.

B2t—16 to 27 inches, reddish-brown (5YR 4/3) silty clay, reddish brown (5YR 4/3) when dry; moderate, coarse and medium, angular blocky structure; very firm when moist, very hard when dry; thin patchy clay films; few, faint, yellowish-brown and brown mottles; neutral; gradual, smooth boundary.

B3—27 to 40 inches, mixed reddish-brown (5YR 4/4) and grayish-brown (2.5Y 5/2) silty clay and silty clay loam, reddish brown (5YR 5/3) and light gray (2.5YR 7/2) when dry; moderate, coarse, angular blocky structure; firm when moist, very hard when dry; few pieces of platy shale; few, distinct, yellowish-brown and brown mottles; few lime concretions; mildly alkaline; gradual, smooth boundary.

R—40 to 50 inches, olive-gray (5Y 5/2) silty clay loam and clayey shale, light gray (5Y 7/2) when dry; firm when moist, hard when dry; common, yellowish-brown mottles; calcareous, moderately alkaline.

The Ap horizon ranges from 5 to 10 inches in thickness. Areas in native sod have an A1 horizon that ranges up to 16 inches in thickness and from black to dark brown. Depth to the partially weathered shale ranges from 20 to 40 inches. The B2t horizon ranges from dark reddish brown to olive brown and is silty clay or heavy silty clay loam.

In mapping unit BKB3, the Benfield soil has a lighter colored A horizon than is defined for the Benfield series, but this difference does not alter its use.

Benfield soils are in the same general areas as Kipson soils, and both formed in material weathered from shale. In contrast with Kipson soils, they have a B horizon, are deeper over shale, and are more acid in the upper part of the profile. They have less grit throughout the profile than Mayberry and Morrill soils, which formed in material reworked from glacial deposits, and are not so deep as those soils.

Benfield silty clay loam, 3 to 9 percent slopes, eroded (BfB2).—This soil occupies small irregularly shaped tracts on ridges and valley sides.

This soil has the profile described as typical for the Benfield series. In some cultivated tracts, plowing exposes the upper part of the subsoil.

This soil has moderate available water capacity and slow permeability. Runoff is rapid. The main concerns of management are controlling erosion and conserving water.

Such drought resistant and close-growing crops as grain sorghum, wheat, and clover are best suited. Corn and soybeans can be grown in rotation with these crops in years of favorable moisture. This soil is also suited to hay, pasture, range, and windbreak plantings. Capability unit IIIe-2; Clayey range site; Silty to Clayey windbreak group.

Benfield-Kipson silty clay loams, 3 to 9 percent slopes, severely eroded (BKB3).—This mapping unit is about 35 percent severely eroded Benfield soils, about 30 percent Benfield silty clay loam, and about 35 percent eroded or severely eroded Kipson soils. These soils occupy small irregularly shaped tracts mainly on valley sides. Kipson soils are on knolls.

The Benfield and Kipson soils in this mapping unit have profiles similar to those described for their respective series, but their surface layer is thinner and lighter colored. Erosion has removed most of the original surface layer. Tillage extends into the clayey subsoil of the severely eroded Benfield soils, and limestone fragments remain on the surface of the eroded and severely eroded Kipson soils.

Tilth is poor, available water capacity is mostly moderate, and the erosion hazard is severe. Controlling erosion, conserving water, and improving tilth and fertility are concerns in management.

These soils are suited to cultivated crops, but are better suited to wheat and other close-growing crops and legume crops, such as clover and alfalfa. Grain sorghum is the most suitable row crop.

In places, these soils occupy small tracts within larger tracts of soils that are suited to cultivation. In these places additions of manure or fertilizer are beneficial.

These soils are well suited to hay, pasture, or range. They are also suited to windbreak plantings and wildlife. Capability unit IVe-4; Benfield soil in Clayey range site and Silty to Clayey windbreak group; Kipson soil in Shallow Limy range site and Shallow windbreak group.

Geary Series

The Geary series consists of deep, well-drained, sloping soils that formed in brown and reddish-brown loess. These soils occupy upland valley sides near some of the major streams in the county.

In the typical profile, the surface layer is dark-brown silty clay loam about 7 inches thick. The subsoil is about 41 inches thick. The upper 7 inches is dark reddish-brown friable silty clay loam; the next 26 inches is reddish-brown, firm silty clay loam; and the lower 8 inches is reddish-brown friable silty clay loam. The underlying material is brown silty clay loam.

Geary soils have moderately slow permeability and high available water capacity. They are slightly acid or medium acid in the upper part of the profile and slightly acid or neutral in the lower part. They are medium to high in natural fertility and are susceptible to erosion.

Most of the acreage is used for cultivated crops or grass. These soils are also suited to windbreak plantings and wildlife.

Typical profile of Geary silty clay loam, 5 to 12 percent slopes, eroded, in a cultivated field, 420 feet east and 135 feet south of the northwest corner of sec. 23, T. 2 N., R. 15 E.:

Ap—0 to 7 inches, dark-brown (7.5YR 3/2) light silty clay loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, blocky structure parting to weak, medium granular; friable when moist, hard when dry; medium acid; abrupt, smooth boundary.

B1—7 to 14 inches, dark reddish-brown (5YR 3/3) silty clay loam, brown (7.5YR 4/3) when dry; weak, coarse, medium and fine, subangular blocky structure; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

B2t—14 to 40 inches, reddish-brown (5YR 4/4) silty clay loam, brown (7.5YR 5/4) when dry; weak, medium, prismatic structure parting to moderate, medium and fine, subangular blocky; firm when moist, hard when dry; shiny surface on peds; neutral; gradual, smooth boundary.

B3—40 to 48 inches, reddish-brown (5YR 4/4) silty clay loam, light brown (7.5YR 6/4) when dry; weak, coarse and medium, subangular blocky structure; friable when moist, hard when dry; common very fine sand and coarse silt on faces of peds; slightly acid; gradual, smooth boundary.

C—48 to 60 inches, brown (7.5YR 4/4) heavy silty clay loam, brown (7.5YR 5/4) when dry; weak, coarse, blocky structure; firm when moist, hard when dry; coarse silt on faces of peds and many very fine sand grains throughout the horizon; slightly acid.

The A horizon ranges from 6 to 10 inches in thickness, from silt loam to silty clay loam in texture, and from black to dark brown in color. The B2t horizon ranges from dark brown to brown to yellowish red.

In the mapping unit GeC3, the Geary soil has a thinner and lighter colored A horizon than is defined for the Geary series, but these differences do not alter its use.

Geary soils are in the same general areas and are similar in texture to Marshall and Sharpsburg soils, but Marshall and Sharpsburg soils formed in Peorian loess and have a less red B horizon. They are similar in color, but have less grit throughout the profile than Morrill soils, which formed in material reworked from glacial deposits.

Geary silty clay loam, 5 to 12 percent slopes, eroded (GeC2).—This soil occupies medium to small tracts on valley sides near drainageways.

This soil has the profile described as typical for the Geary series. Included in mapping were small tracts of Morrill, Sharpsburg, and Marshall soils.

Tilth is good, and permeability is moderately slow. Unless this soil is protected, it is subject to runoff and further erosion. Controlling erosion is a necessary part of good management.

This soil is suited to all crops and grasses commonly grown in the county. It is also suited to windbreak plantings and wildlife. Capability unit IIIe-1; Silty range site; Silty to Clayey windbreak group.

Geary silty clay loam, 5 to 12 percent slopes, severely eroded (GeC3).—This soil occupies small irregularly shaped tracts on valley sides near drainageways.

This soil has a profile similar to the one described as typical for the Geary series, but most of the original surface layer has been removed by erosion. The present surface layer is brown or reddish brown and has been mixed with material from the upper subsoil.

The organic-matter content is low, runoff is rapid, and the erosion hazard is severe. Controlling erosion and increasing fertility are the main concerns of management.

This soil is not well suited to continuous row cropping. It is suited to wheat, grain sorghum, clover, and alfalfa. It is well suited to hay, pasture, and range. Most of the acreage is cultivated. Capability unit IVe-8; Silty range site; Silty to Clayey windbreak group.

Gullied Land

Gullied land (31 to 65 percent slopes) (Gl) occupies narrow tracts along deep drainageways. It consists mainly of nearly vertical, actively eroding slopes of gullies. In places banks are stable. Drainageways have cut through various kinds of material including loess, alluvium, and glacial material. Many drainageways in the county have deepened channels, but they are too small to be shown as Gullied land on the soil map.

Gullied land is useful only for wildlife. It is not suited to pasture because of the severe erosion hazard, the sparse vegetation, and the danger of injury to livestock. Capability unit VIIIe-1; no range site designation; Undesirable windbreak group.

Haynie Series

The Haynie series consists of deep, moderately well drained, nearly level soils that formed in loamy alluvium. These soils are on bottom land of the Missouri River Valley.

In a typical profile, the surface layer is very dark grayish-brown silt loam about 7 inches thick. The underlying material is stratified, dark grayish-brown and brown, very friable silt loam and very fine sandy loam to a depth of 60 inches.

Haynie soils have moderate permeability and high available water capacity. They are mildly alkaline to moderately alkaline throughout the profile. They are high in natural fertility and have good tilth. Unless these soils are protected by levees, they are subject to occasional overflow.

Most of the acreage is cultivated. Small areas subject to overflow have not been cleared and have a dense to sparse cover of young trees and shrubs and a variable understory of grasses.

Typical profile of Haynie silt loam, in a cultivated field north of road, 0.3 mile east and 0.15 mile south of the northwest corner of sec. 22, T. 3 N., R. 17 E.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, coarse, blocky structure parting to weak, fine, granular; very friable when moist, soft when dry; calcareous; moderately alkaline; abrupt, smooth boundary.

C—7 to 60 inches, stratified, dark grayish-brown (10YR 4/2) and brown (10YR 4/3) silt loam and very fine sandy loam, light brownish gray (10YR 6/2) and pale brown (10YR 6/3) when dry; weak, medium, platy structure and weak, medium, subangular blocky structure; very friable when moist, soft when dry; few, fine, dark yellowish-brown and reddish-brown mottles; calcareous; moderately alkaline.

The Ap horizon ranges from silt loam to very fine sandy loam. In places, the C horizon contains thin strata of sandy loam.

Haynie soils are in the same general areas as Albaton and Sarpy soils. They are loamy and have less sand throughout the profile than Sarpy soils. They have less clay throughout the profile than Albaton soils. They are not so dark colored as Kennebec soils, which are on bottom lands of the Nemaha River, and they are less acid.

Haynie silt loam (0 to 1 percent slopes) (He).—This soil is on the Missouri River bottom land. It has the profile described as typical for the Haynie series. Included in mapping were small tracts of Sarpy loamy fine sand and Albaton silty clay.

Tilth is good and permeability is moderate. The main concern of management is overflow, which occurs every 1 to 3 years. In places, this soil is protected from flooding by levees.

Most of the acreage is cultivated. Corn is the main crop, but soybeans, wheat, grain sorghum, clover, and alfalfa are suitable crops. This soil is also suited to grasses and trees. Capability unit IIw-3; Silty Lowland range site; Moderately Wet windbreak group.

Haynie and Albaton soils (0 to 1 percent slopes) (HA).—In most areas this mapping unit is about 40 percent Haynie silt loam, 20 percent Albaton silty clay, and 40 percent a soil of stratified silt loam and silty clay loam that is about 20 inches thick over a 40-inch layer of highly stratified silty clay loam, silty clay, and silt loam. These soils occupy broad tracts on the bottom land of the Missouri River.

Occasional overflow is a hazard. Otherwise these soils have few limitations. In places, they are protected from flooding by levees. During periods of heavy rainfall, tilth and wetness limit the use of the Albaton soil.

Grain sorghum, soybeans, corn, wheat, alfalfa, and clover are suitable crops. Grasses and trees are also suited. Most of the acreage is cultivated. Capability unit IIw-3; Haynie soil in Silty Lowland range site and Moderately Wet windbreak group; Albaton soil in Clayey Overflow range site and Moderately Wet windbreak group.

Haynie and Sarpy soils (0 to 2 percent slopes) (HS).—In most areas this mapping unit is about 50 percent Haynie silt loam, 20 percent Sarpy loamy fine sand, and about 30 percent a soil of stratified fine sandy loam and loamy fine sand that is about 20 inches thick over a 40-inch layer of highly stratified silt loam, very fine sandy loam, and silty clay loam. These soils occupy tracts on the bottom land of the Missouri River. The Sarpy soil is in gently undulating areas or areas that are slightly higher than the other soils in this mapping unit. It is low in organic-matter content, low in available water capacity, and is susceptible to soil blowing.

Tilth is good and permeability is moderate to rapid. Occasional overflow is the main concern of management. In a few places, levees protect these soils from overflow. Good farming practices are a necessary part of good management.

Most of the acreage is cultivated. Grain sorghum, corn, soybeans, wheat, clover, and alfalfa are suitable crops. These soils are also suited to grasses and wildlife. Capability unit IIw-3; Haynie soil in Silty Lowland range site and Moderately Wet windbreak group; Sarpy soil in Sandy Lowland range site and Sandy windbreak group.

Hobbs Series

The Hobbs series consists of deep, moderately well drained, nearly level soils that formed in silty alluvium. These soils are on the bottom land along the Nemaha River and Muddy Creek.

In a typical profile, the surface layer is very dark grayish-brown silt loam about 32 inches thick. It is faintly stratified with dark gray and dark brown; strata are 1 to 3 inches thick. The surface layer is underlain by very dark grayish-brown, friable heavy silt loam that extends to a depth of 60 inches. It is faintly stratified with very dark brown; strata are 1 to 6 inches thick.

Hobbs soils have moderate permeability and high available water capacity. They are neutral to slightly acid throughout the profile. They are high in natural fertility and have good tilth. Hobbs soils have few limitations for farming, but are subject to an occasional overflow.

These soils are well suited to cultivated crops. Nearly all of the acreage is cultivated. In places, small odd-shaped tracts are used for grass and deciduous trees grow along the edges of stream channels.

Typical profile of Hobbs silt loam, in a cultivated field, 0.13 mile east and 165 feet north of the southwest corner of sec. 6, T. 1 N., R. 17 E.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when dry; weak, fine, granular structure; very friable when moist, soft when dry; neutral; abrupt, smooth boundary.

A12—7 to 32 inches, very dark grayish-brown (10YR 3/2) silt loam faintly stratified with 1- to 3-inch layers of dark-gray (10YR 4/1) and dark-brown (10YR 3/3) silt loam, grayish brown (10YR 5/2) when dry; weak, medium and fine, granular structure; very friable when moist, soft when dry; slightly acid; gradual, wavy boundary.

AC—32 to 60 inches, very dark grayish-brown (10YR 3/2), heavy silt loam faintly stratified with 1- to 6-inch layers of very dark brown (10YR 2/2) silt loam, grayish brown (10YR 5/2) when dry; weak, medium and fine, subangular blocky structure; friable when moist, hard when dry; few, faint, dark yellowish-brown and reddish-brown mottles below a depth of 42 inches; slightly acid to neutral.

The combined thickness of the Ap and A12 horizons ranges from 20 to 40 inches. Structure ranges from weak, coarse, platy to moderate, medium, granular. The AC horizon ranges from 5 to 35 inches in thickness and from very dark brown to grayish brown in color. Structure is weak, coarse to fine, subangular blocky; moderate to weak, medium, granular; or weak, fine to coarse, platy.

Hobbs soils are in the same general areas as Kennebec and Nodaway soils. They are somewhat more stratified than Kennebec soils and are not so dark colored. They are less stratified and have a thicker and darker A horizon than Nodaway soils.

Hobbs silt loam (0 to 1 percent slopes) (Hv).—This soil is on the bottom land along the Nemaha River and Muddy Creek.

This soil is easy to work. Permeability is moderate, and available water capacity is high. Overflow is a slight concern in management. This soil is flooded about once every 2 to 5 years.

This soil is well suited to cultivated crops. Nearly all the acreage is cultivated. Capability unit IIw-3; Silty Lowland range site; Moderately Wet windbreak group.

Ida Series

The Ida series consists of deep, well-drained, moderately steep to steep soils that formed in brownish silt loam loess. These soils are on uplands.

In a typical profile, the surface layer is brown silt loam about 5 inches thick. The underlying material consists of very friable silt loam that extends to a depth of 60 inches. The upper 21 inches is dark yellowish brown, the next 5 inches is yellowish brown, and the lower 29 inches is light brownish gray.

Ida soils have moderate permeability, high available water capacity, and rapid runoff. They are mildly alkaline to moderately alkaline throughout the profile. They are medium in natural fertility, moderately low in organic-matter content, and are susceptible to erosion.

Nearly all the acreage has been cultivated, but some areas are now used for grasses or legumes, to which the soils are well suited.

Typical profile of Ida silt loam, 12 to 17 percent slopes, eroded, 0.3 mile west and 102 feet south of the northeast corner of sec. 24, T. 3 N., R. 16 E.:

Ap—0 to 5 inches, brown (10YR 4/3) silt loam, pale brown (10YR 6/3) wen dry; weak, coarse, blocky structure parting to weak, fine, granular; very friable when moist, slightly hard when dry; calcareous; common lime concretions; moderately alkaline; abrupt, smooth boundary.

C1—5 to 26 inches, dark yellowish-brown (10YR 4/4) silt loam, light yellowish brown (10YR 6/4) when dry; weak, coarse, prismatic structure; very friable when moist, slightly hard when dry; calcareous; few lime concretions; moderately alkaline; gradual, smooth boundary.

C2—26 to 31 inches, yellowish-brown (10YR 5/8) silt loam, brownish yellow (10YR 6/6) when dry; weak, coarse, prismatic structure; very friable when moist, slightly hard when dry; few dark accumulations (iron or manganese oxides); common, fine, distinct, gray mottles; calcareous; moderately alkaline; gradual boundary.

C3—31 to 60 inches, light brownish-gray (2.5Y 6/2) silt loam, pale yellow (2.5Y 7/4) when dry; weak, coarse, prismatic structure; very friable when moist, slightly hard when dry; common, medium, yellowish-brown mottles and common, coarse, gray mottles; few dark accumulations (iron or manganese oxides); calcareous; few lime concretions; moderately alkaline.

The A horizon is very dark grayish brown, dark brown, or brown. In places, it is noncalcareous.

Ida soils formed in the same kind of parent material and are in the same general areas as Monona soils. They are more alkaline and have a thinner, lighter colored A horizon than those soils.

Ida silt loam, 12 to 17 percent slopes, eroded (IdD2).—This soil occupies small tracts on convex hillsides near small drainageways.

This soil has the soil profile described as typical for the Ida series. Included in mapping were small tracts of Monona silt loam, 12 to 17 percent slopes, eroded, and few to many small areas of an eroded grayish soil moderately low in phosphorus.

The organic-matter content is moderately low, runoff is rapid, and the erosion hazard is severe. The main concern of management is the erosion hazard. Maintaining high fertility is a minor concern. Farm machinery is difficult to operate on this moderately steep soil.

This soil is not well suited to continuous row cropping. It is suited to wheat, grain sorghum, clover, and alfalfa. It is well suited to hay, pasture, range, and wildlife. Capability unit IVe-8; Limy Upland range site; Silty to Clayey windbreak group.

Ida silt loam, 17 to 30 percent slopes, eroded (IdF2).—This steep soil occupies small tracts on the uplands. It has a profile similar to the one described as typical of the series, but the surface layer is slightly thinner.

Included in mapping were small tracts of Monona silt loam, 17 to 30 percent slopes, and few to many small areas of an eroded. grayish soil low in phosphorus.

The organic-matter content is moderately low, and runoff is very rapid. The erosion hazard is too severe and slopes are too steep for continuous tillage. Concerns of management are controlling erosion and establishing and maintaining plants for permanent cover.

This soil is suited to perennial grasses. Small areas are suited to hay and wildlife. Capability unit VIe-8; Limy Upland range site; Silty to Clayey windbreak group.

Judson Series

The Judson series consists of deep, well-drained, very gently sloping and gently sloping soils. These soils formed in silty sediment eroded from dark-colored soils that formed in loess. They are on foot slopes and alluvial fans adjacent to uplands.

In a typical profile, the surface layer is very dark brown heavy silt loam about 22 inches thick. The subsoil is about 23 inches thick. The upper 9 inches is very dark grayish-brown, friable light silty clay loam, and the lower 14 inches is dark-brown, friable silty clay loam. The underlying material is dark yellowish-brown silty clay loam.

Judson soils have moderate to moderately slow permeability and high available water capacity. They are medium acid or slightly acid in the upper and middle parts of the profile and are slightly acid or neutral in the lower part. They are high in natural fertility.

Most of the acreage is cultivated. These soils are also suited to grasses and trees.

Typical profile of Judson silt loam, 1 to 4 percent slopes, in a cultivated field, 180 feet west and 150 feet north of the southeast corner of sec. 6, T. 1 N., R. 17 E.:

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

A12—8 to 18 inches, very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) when dry; weak, medium, subangular blocky structure parting to weak, fine, granular; friable when moist, slightly hard when dry; medium acid; gradual, smooth boundary.

A3—18 to 22 inches, very dark brown (10YR 2/2) heavy silt loam, very dark grayish brown (10YR 3/2) when dry; weak, medium, fine and very fine, subangular blocky structure; friable when moist, hard when dry; medium acid; gradual, smooth boundary.

B2—22 to 31 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, dark brown (10YR 3/3) when dry; weak, coarse, medium and fine, subangular blocky structure; friable when moist, hard when dry; medium acid; gradual, smooth boundary.

B3—31 to 45 inches, dark-brown (10YR 4/3) silty clay loam, brown (10YR 5/3) when dry; weak, coarse, medium and fine, subangular blocky structure; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

C—45 to 60 inches, dark yellowish-brown (10YR 4/4) silty clay loam, yellowish-brown (10YR 5/4) when dry; weak, coarse and medium, prismatic structure; friable when moist, hard when dry; few, fine, faint, gray mottles and few dark accumulations (iron or manganese oxides); slightly acid.

The combined thickness of the Ap, A12, and A3 horizons ranges from 15 to 30 inches, and the texture ranges from silt loam to silty clay loam. In places, the A12 horizon is black. The B2 horizon ranges from 5 to 12 inches in thickness. The B3 horizon ranges from 10 to 18 inches in thickness. Structure of the B2 and B3 horizons ranges from weak to strong and from fine granular to coarse subangular blocky.

Judson soils are in the same general areas as Kennebec soils, but are upslope from those soils and in contrast, have a B horizon. They have a thicker A horizon than Sharpsburg and Marshall soils, which are on the adjacent uplands.

Judson silt loam, 1 to 4 percent slopes (JuA).—This soil occupies narrow to broad tracts at the foot of uplands.

In places it occupies narrow valleys of small drainageways.

Included in mapping were some areas of Kennebec soils and small areas of soils that have a surface layer of loam or silty clay loam, which is material washed from nearby soils that formed in glacial deposits or material derived from shale.

Tilth is good, and permeability is moderate to moderately slow. Some water runs off this soil during heavy rainstorms. In places runoff from the adjacent uplands is a hazard. Controlling erosion is a concern in management.

This soil is suited to all crops commonly grown in the county. Most of the acreage is cultivated. Some narrow tracts along drainageways are used for pasture. Capability unit IIe–1; Silty Lowland range site; Silty to Clayey windbreak group.

Kennebec Series

The Kennebec series consists of deep, well-drained, nearly level soils that formed in silty alluvium. These soils are on the bottom land along the Nemaha River and its tributaries.

In a typical profile, the surface layer is silt loam about 34 inches thick. The upper 12 inches is very dark brown, the next 14 inches is black, and the lower 8 inches is very dark gray. The 4-inch transitional layer between the surface layer and underlying material is very dark grayish-brown, friable heavy silt loam. The underlying material, to a depth of 60 inches, is friable silty clay loam. It is very dark grayish brown in the upper part and dark gray in the lower part.

Kennebec soils have moderate permeability. They are high in available water capacity and are neutral to slightly acid throughout the profile. They are high in natural fertility, have good tilth, and have few limitations for farming.

Nearly all of the acreage is cultivated. Odd shaped tracts are used for grass. Deciduous trees grow along the edges of stream channels.

Typical profile of Kennebec silt loam, 0.45 mile west and 135 feet north of the southwest corner of sec. 7, T. 2 N., R. 17 E.:

Ap—0 to 7 inches, very dark brown (10 YR 2/2) silt loam, dark gray (10YR 4/1) when dry; weak, fine, granular structure; very friable when moist, soft when dry; neutral; abrupt, smooth boundary.

A12—7 to 12 inches, very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) when dry; compound, weak, coarse, medium, and fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

A13—12 to 26 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; compound, weak, coarse, medium, and fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

A14—26 to 34 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) when dry; compound, weak, coarse, medium, and fine, subangular blocky structure; friable when moist, slightly hard when dry; slightly acid; gradual, smooth boundary.

AC—34 to 38 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, gray (10YR 5/1) when dry; compound, weak coarse, medium, and fine, subangular blocky structure; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

C1—38 to 44 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) when dry; compound, weak, coarse, blocky structure parting to weak, medium, subangular blocky; friable when moist, hard when dry; few, small, dark accumulations (iron or manganese oxides); slightly acid; gradual, smooth boundary.

C2—44 to 60 inches, dark-gray (10YR 4/1) silty clay loam, grayish brown (10YR 5/2) when dry; few, fine, faint, brown and grayish-brown mottles; weak, coarse, blocky structure; friable when moist, hard when dry; few small dark accumulations (iron or manganese oxides); slightly acid.

In places Kennebec soils have very dark grayish-brown (10YR 3/2) or dark grayish-brown (10YR 4/2) silt loam overwash sediment 6 to 14 inches thick. The C1 and C2 horizons range from silt loam to heavy silty clay loam.

Kennebec soils are in the same general areas as Judson, Hobbs, Zook, and Wabash soils. They are downslope from Judson soils and in contrast, do not have a B horizon. They have a darker A horizon and are somewhat less stratified than Hobbs soils. They have less clay throughout the profile and are less wet than Zook and Wabash soils. They are darker colored and more acid than Haynie soils, which are on the bottom land of the Missouri River.

Kennebec silt loam (0 to 1 percent slopes) (Ke).—This soil occupies broad tracts on the bottom land of the Nemaha River and narrow, irregularly shaped tracts along tributary drainageways.

Included in mapping were small tracts of Hobbs silt loam, Judson silt loam, 1 to 4 percent slopes, and Zook silty clay loam.

This soil is well drained and is easy to work. It can be farmed intensively without risk of damage, and it responds well to good management. Permeability is mostly moderate, and available water capacity is high.

This soil is suited to all crops commonly grown in the county. Except for small grassy areas along streams, nearly all the acreage is cultivated. Corn, grain sorghum, and soybeans are the principal crops. Capability unit I–1; Silty Lowland range site; Silty to Clayey windbreak group.

Kipson Series

The Kipson series consists of soils that are shallow over silty to clayey shales (fig. 5). These soils are somewhat excessively drained, gently sloping to steep upland soils that are on ridgetops and sides of drainageways.

In a typical profile, the surface layer is very dark brown, calcareous light silty clay loam about 12 inches thick. Fragments of limestone are common. The 8-inch layer of underlying material also contains limestone fragments, but is dominantly grayish-brown light silty clay loam. Below this is mixed light-gray silt loam and olive-gray clayey shale.

Kipson soils have moderate permeability in the surface layer and underlying material but have slow permeability in the shale substratum. They are low in available water capacity. They are calcareous and mildly alkaline to moderately alkaline throughout the profile. Kipson soils are medium in natural fertility and are susceptible to erosion.

Most of the acreage is used for native range, hay, or tame pasture, to which it is well suited. In places small areas of Kipson soils intermingled with other soils are cultivated. Such deciduous trees as Osage-orange and locust and woody shrubs have invaded some areas of Kipson soils.

Figure 5.—**Profile of Kipson silty clay loam showing 6- to 12-inch surface layer, wavy boundary above underlying material, and limestone fragments in underlying material. Shale is at a depth of about 20 inches.**

Typical profile of Kipson silty clay loam from an area of Kipson-Sogn complex, 3 to 30 percent slopes, 0.12 mile east and 540 feet north of the center of sec. 27, T. 1 N., R. 13 E.:

A—0 to 12 inches, very dark brown (10YR 2/2) light silty clay loam, very dark gray (10YR 3/1) when dry; moderate, medium, angular blocky structure parting to weak, medium and coarse, granular; friable when moist, hard when dry; about 10 percent, by volume, limestone fragments ¼ inch to 1 inch in size; calcareous; mildly alkaline; gradual, wavy boundary.

C—12 to 20 inches, grayish-brown (2.5Y 5/2) light silty clay loam, light brownish gray (2.5Y 6/2) when dry; moderate, medium and fine, angular blocky structure; friable when moist, hard when dry; about 15 percent, by volume, limestone fragments ¼ inch to 3 inches in size; calcareous; moderately alkaline; clear, wavy boundary.

R—20 to 40 inches, mixed light-gray (5Y 7/2) silt loam and olive-gray (5Y 5/2) clayey shale, white (5Y 8/1) and light gray (5Y 7/2) when dry; very firm when moist, very hard when dry; few, distinct, brown mottles; calcareous; moderately alkaline.

The depth to shale bedrock ranges from 7 to 20 inches. The A horizon ranges from 6 to 12 inches in thickness and from black to very dark grayish brown in color. Some profiles have an AC horizon that ranges from 5 to 10 inches in thickness and is intermediate in color between the A and C horizons. Thin flat limestone fragments on the surface make up to 25 percent of the soil mass in some places.

Kipson soils are in the same general areas as Benfield and Sogn soils. In contrast with Benfield soils, they do not have a B horizon, are less acid in the upper part of the profile, and are shallower to shale. They are shallow over shale, whereas Sogn soils are shallow over limestone.

Kipson-Benfield silty clay loams, 9 to 17 percent slopes (KBD).—This mapping unit is about 40 percent Kipson silty clay loam, about 40 percent Benfield silty clay loam, about 10 percent very shallow soils that are similar to Kipson soils but have many limestone fragments on the surface, and about 10 percent Morrill soils. These soils have uneven slopes. They occupy medium and small irregular tracts on valley sides near drainageways.

The Kipson and Benfield soils have profiles similar to those described as typical of their series, but the Kipson soil has a thinner surface layer.

Included in mapping were soils that formed in thin beds of reddish shale, and in places, small areas of Gullied land and Silty alluvial land and areas of Judson, Wymore, and Sogn soils.

Available water capacity is low to moderate, and runoff is rapid. The hazard of erosion is too severe and slopes are too uneven and steep for continuous tillage. Controlling erosion and establishing and maintaining plants for permanent cover are concerns of management.

These soils are suited to hay, pasture, and range. They are also suited to wildlife. Many areas are used for pasture or range. Some tracts formerly were cropland, but are now idle. Osage-orange and locust trees grow in these areas. Capability unit VIs-4; Kipson soil in Shallow Limy range site and Shallow windbreak group; Benfield soil in Clayey range site and Silty to Clayey windbreak group.

Kipson-Sogn complex, 3 to 30 percent slopes (KSD).—This mapping unit is about 35 percent Kipson silty clay loam, about 30 percent very shallow soils that are similar to Kipson soils and contain numerous outcrops of rock or fragments, about 25 percent Sogn soils, and about 10 percent Benfield silty clay loam. This complex occupies many large to small irregularly shaped tracts on high bedrock ridges and on valley sides next to drainageways. Except for the number of stones on the surface, the Kipson, Sogn, and Benfield soils have profiles similar to those described for their respective series.

Included in mapping were cherty soils on some of the highest bedrock ridges, particularly in sections 34 and 35, T. 1 N., R. 13 E. and sections 31 and 32, T. 1 N., R. 14 E. Also included are small tracts of Gullied land and Judson and Wymore soils along drainageways.

Available water capacity is low or very low, and runoff is very rapid. The erosion hazard is very severe. The soils are too stony and too steep for tillage. Controlling runoff and erosion, conserving moisture, and establishing and maintaining plants for permanent cover are concerns in management.

These soils are suited to pasture, range, and wildlife. Most areas are used for pasture or range, but some have a cover of shrubs, Osage-orange, and locust trees. Capability unit VIIs-3; Shallow Limy range site; Shallow windbreak group.

Marshall Series

The Marshall series consists of deep, well-drained, nearly level to strongly sloping soils that formed in pale-brown, yellowish-brown, or light olive-brown loess. These soils are on uplands.

In a typical profile, the surface layer is very dark brown light silty clay loam about 12 inches thick. The subsoil is friable silty clay loam about 29 inches thick. The upper 5 inches is dark brown, the next 18 inches is brown, and the lower 6 inches is dark yellowish brown. The underlying material consists of yellowish-brown light silty clay loam in the upper 14 inches and light olive-brown silt loam in the lower 5 inches.

Marshall soils have moderately slow permeability and high available water capacity. They are high in natural fertility. They are medium acid or slightly acid in the surface layer and upper part of the subsoil and are slightly acid or neutral in the lower part.

Most of the acreage is cultivated. These soils are also suited to grasses, orchards, and windbreaks.

Typical profile of Marshall silty clay loam, 2 to 5 percent slopes, 0.2 mile south and 90 feet west of the northeast corner of sec. 15, T. 2 N., R. 16 E.:

A—0 to 12 inches, very dark brown (10YR 2/2) light silty clay loam, very dark grayish brown (10YR 3/2) when dry; weak, medium and fine, granular structure; friable when moist, slightly hard when dry; medium acid; gradual, smooth boundary.

B1—12 to 17 inches, dark-brown (10YR 3/3) silty clay loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, subangular blocky structure parting to weak, fine, subangular blocky; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

B2—17 to 35 inches, brown (10YR 4/3) silty clay loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure parting to moderate, medium and fine, subangular blocky; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

B3—35 to 41 inches, dark yellowish-brown (10YR 4/4) silty clay loam, yellowish brown (10YR 5/4) when dry; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; friable when moist, hard when dry; few, fine, strong-brown and gray mottles; few dark accumulations (iron or manganese oxides); neutral; gradual, smooth boundary.

C1—41 to 55 inches, yellowish-brown (10YR 5/4) light silty clay loam, light yellowish brown (10YR 6/4) when dry; weak, coarse and medium, prismatic structure; friable when moist, slightly hard when dry; common, fine, strong-brown, brownish-yellow, and gray mottles; many dark accumulations (iron or manganese oxides); neutral; gradual, smooth boundary.

C2—55 to 60 inches, light olive-brown (2.5Y 5/4) silt loam, light yellowish brown (10YR 6/4) when dry; weak, coarse, prismatic structure; very friable when moist, soft when dry; many, fine, gray and brown mottles; many dark accumulations (iron or manganese oxides); neutral.

The A horizon ranges from 7 to 18 inches in thickness and from black to very dark grayish brown in color. The B1 horizon ranges from 4 to 8 inches in thickness, the B2 horizon from 12 to 20 inches, and the B3 horizon 5 to 15 inches.

The Marshall soil in mapping unit MaC3 has a thinner and lighter colored A horizon than is defined for the series, but these differences do not alter its use.

Marshall soils are in the same general areas as the Sharpsburg, Monona, and Geary soils. They have less clay in the B horizon than Sharpsburg soils, but they have more clay and are slightly more acid in the B horizon than Monona soils. They are similar in texture to Geary soils, but Geary soils formed in Loveland loess and have a redder B horizon.

Marshall silty clay loam, 0 to 2 percent slopes (MaA)—This soil occupies tracts on upland divides. It has a profile similar to the one described as typical of the series, but the surface layer is slightly thinner.

Included in mapping were small tracts of Sharpsburg silty clay loam, 0 to 2 percent slopes.

This soil is well drained and is easy to work. If well managed, it can be farmed intensively without risk of damage. Permeability is moderately slow, and available water capacity is high.

Most of the acreage is cultivated. This soil is suited to corn, soybeans, grain sorghum, wheat, clover, and alfalfa. It is also suited to grasses and windbreak plantings. Capability unit I-1; Silty range site; Silty to Clayey windbreak group.

Marshall silty clay loam, 2 to 5 percent slopes (MaB).—This soil occupies narrow to broad tracts on upland ridgetops.

This soil has the profile described as typical for the Marshall series. Included in mapping were small areas of Sharpsburg silty clay loam, 2 to 5 percent slopes, eroded.

Tilth is good, permeability is moderately slow, and available water capacity is high. Some water runs off this soil during heavy rainstorms. Controlling erosion is a concern in management.

Most of the acreage is cultivated. This soil is suited to all crops commonly grown in the county. It is also suited to grasses and windbreak plantings. Capability unit IIe-1; Silty range site; Silty to Clayey windbreak group.

Marshall silty clay loam, 5 to 12 percent slopes, eroded (MaC2).—This soil has smooth slopes. It occupies many broad, irregularly shaped tracts on valley sides below ridgetops.

This soil has a soil profile similar to the one described as typical for the Marshall series, but the surface layer and subsoil are a few inches thinner. Included in mapping were small tracts of Marshall silty clay loam, 5 to 12 percent slopes, severely eroded.

This soil has good workability. Permeability is moderately slow, available water capacity is high, and runoff is medium to rapid. The erosion hazard is severe. The main concern of management is water erosion.

Nearly all the acreage is cultivated. This soil is suited to corn, grain sorghum, soybeans, wheat, clover, and alfalfa. It is also suited to grasses and trees. Capability unit IIIe-1; Silty range site; Silty to Clayey windbreak group.

Marshall silty clay loam, 5 to 12 percent slopes, severely eroded (MaC3).—This soil occupies small to large, irregularly shaped tracts on valley sides.

This soil has a profile similar to the one described as typical for the Marshall series, but the surface layer is thinner and lighter colored because of water erosion. For the most part, tillage is in the upper part of the original subsoil. The surface layer is brown or dark brown and is 5 to 8 inches thick. Included in mapping were small areas of Geary silty clay loam, 5 to 12 percent slopes, severely eroded; Sharpsburg silty clay loam, 3 to 12 percent slopes, severely eroded; and Monona silt loam, 5 to 12 percent slopes, eroded.

The organic-matter content is moderately low, permeability is moderately slow, and available water capacity is high. Runoff is rapid. Unless protected, this soil is subject to further erosion. It is responsive to good management. Controlling water erosion and increasing fertility are the main concerns.

Most of the acreage is cultivated. This soil is suited to all crops commonly grown in the county. It is also suited to grasses and trees. Capability unit IIIe-8; Silty range site; Silty to Clayey windbreak group.

Mayberry Series

The Mayberry series consists of deep, moderately well drained, gently sloping to strongly sloping soils that formed in brown and reddish-brown material reworked from glacial deposits. These soils are on uplands.

In a typical profile, the surface layer is very dark brown clay loam about 8 inches thick. The subsoil is 46 inches thick. The upper 10 inches is mixed very dark grayish-brown and dark reddish-brown firm clay loam; the next 36 inches is mottled dark-brown, brown, and yellowish-red very firm clay and sandy clay. The underlying material is stratified mottled, reddish-brown, brown, strong-brown, light brownish-gray and light olive-gray sandy loam, silty clay loam, and clay.

Mayberry soils have slow permeability and moderate available water capacity. They are medium to high in natural fertility. They are medium acid to slightly acid in the surface layer and upper subsoil and are neutral or slightly acid in the middle and lower parts of the subsoil. Mayberry soils are susceptible to erosion.

These soils are used for cultivated crops, grass, windbreaks, and wildlife.

The Mayberry soils in Richardson County are mapped only with Pawnee soils.

Typical profile of Mayberry clay loam, in an area of Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded, 0.25 mile south and 360 feet east of the northwest corner of sec. 32, T. 2 N., R. 13 E.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) clay loam, dark grayish brown (10YR 4/2) when dry; moderate, fine and medium, granular structure; friable when moist, hard when dry; slightly acid to medium acid; clear, smooth boundary.

B1—8 to 18 inches, mixed 50 percent very dark grayish-brown (10YR 3/2) and 50 percent dark reddish-brown (5YR 3/4) heavy clay loam, dark grayish brown (10YR 4/2) and reddish brown (5YR 4/4) when dry; moderate, very fine, subangular blocky structure; firm when moist, hard when dry; medium acid; clear, smooth boundary.

B2t—18 to 46 inches, mottled 50 percent dark-brown (10YR 4/3) and 50 percent yellowish-red (5YR 4/6) clay, brown (10YR 5/3) and reddish brown (5YR 5/4) when dry; moderate, medium, angular blocky structure; very firm when moist, extremely hard when dry; shiny faces on peds; common, fine, dark accumulations; slightly acid in upper part to neutral in lower part; gradual, smooth boundary.

B3t—46 to 54 inches, mottled and stratified, brown (10YR 5/3) and yellowish-red (5YR 4/6) clay and sandy clay, pale brown (10YR 6/3) and reddish brown (5YR 5/4) when dry; weak, medium and coarse, angular blocky structure; very firm when moist, extremely hard when dry; shiny faces on peds; common, fine, dark accumulations; neutral; clear, smooth boundary.

C—54 to 60 inches, mottled and stratified, reddish-brown (5YR 4/4), brown (10YR 5/3), strong-brown (7.5YR 5/6), light brownish-gray (2.5Y 6/2) and light olive-gray (5Y 6/2) sandy loam, silty clay loam, and clay, reddish brown (5YR 5/4), brown (10YR 5/3), pale brown (10YR 6/3), yellowish brown (10YR 5/6), and light gray (10YR 7/2) when dry; compound, weak, coarse, blocky structure and weak, fine, platy structure; friable to firm when moist, hard when dry; many, fine, dark accumulations; neutral.

The Ap horizon ranges from 4 to 8 inches in thickness. Areas in native sod have an A1 horizon up to 15 inches thick, and the upper 6 to 9 inches is black silt loam or loam. In places, the B1 horizon is absent, and the A horizon is underlain by the B2t horizon. The B2t ranges from 28 to 40 inches in thickness. The B3t horizon ranges from 8 to 34 inches in thickness and in places is not stratified and contains more silt.

In mapping unit PAD3, the Mayberry soils have a thinner and lighter colored A horizon than is defined in the range for the series, but this difference does not alter the usefulness of the soils.

Mayberry soils are in the same general areas as Pawnee and Morrill soils. They have a clay B horizon similar to that in Pawnee soils, but redder. They are similar to Morrill soils in color, but they have more clay in the B horizon. They have more grit throughout the profile than Benfield soils, which formed in silty and clayey shales.

Monona Series

The Monona series consists of deep, well-drained, very gently sloping to steep soils that formed in yellowish-brown loess. These soils are on the uplands in an area about 6 miles wide, parallel and adjacent to the Missouri River Valley.

In a typical profile, the surface layer is very dark grayish-brown silt loam about 10 inches thick. The subsoil is very friable silt loam about 24 inches thick (fig. 6). The upper 7 inches is dark brown, and the rest is dark yellowish brown. The underlying material is yellowish-brown silt loam.

Monona soils have moderate permeability and high available water capacity. They are slightly acid in the surface layer, neutral in the subsoil, and neutral or mildly alkaline in the underlying material. They are high in natural fertility.

Monona soils are principally used for crops. Grasses and deciduous trees grow on the steeper slopes. These soils are suitable for windbreaks and wildlife.

Typical profile of Monona silt loam, 5 to 12 percent slopes, 265 feet south and 145 feet west of the northeast corner of the SE1/4 sec. 12, T. 3 N., R. 16 E.:

Ap—0 to 10 inches, very dark grayish-brown (10YR 3/2) silt loam, dark grayish brown (10YR 4/2) when dry; weak, coarse and medium, blocky structure parting to weak, fine, granular; very friable when moist, slightly hard when dry; slightly acid; clear, smooth boundary.

B1—10 to 17 inches, dark-brown (10YR 3/3) silt loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, medium and fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

B2—17 to 25 inches, dark yellowish-brown (10YR 3/4) silt loam, brown (10YR 5/3) when dry; weak, coarse, medium and fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

B3—25 to 34 inches, dark yellowish-brown (10YR 4/4) silt loam, yellowish brown (10YR 5/4) when dry; weak, medium, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

C—34 to 60 inches, yellowish-brown (10YR 5/4) silt loam, light yellowish brown (10YR 6/4) when dry; weak, coarse, prismatic structure; very friable when moist, slightly hard when dry; common, faint to prominent grayish-brown and strong-brown mottles; mildly alkaline.

The A horizon ranges from 7 to 18 inches in thickness, and it is black, very dark brown, or very dark grayish brown. In places, the C horizon is calcareous below a depth of about 36 inches.

The eroded soils in mapping units MnC2 and MnD2 and in places in mapping unit MnF have a lighter colored, thinner A horizon than is defined in the range for the Monona series. These differences, however, do not alter the usefulness of the soils.

Monona soils are near Ida and Marshall soils. In contrast with Ida soils, they have a B horizon, are free of carbonates, are more acid, and have a darker A horizon. They have less clay and are less acid in the B horizon than Marshall soils.

Monona silt loam, 1 to 5 percent slopes (MnB).—This soil occupies narrow to broad tracts on divides and ridgetops. It has a profile similar to the one described as typical of the series, but the surface layer is slightly thinner.

Included in mapping were areas of Marshall soils.

This soil is well drained and is easy to work. Permeability is moderate, and available water capacity is high. Some water runs off this soil during heavy rainstorms. The hazard of erosion is slight.

Nearly all areas are cultivated. This soil is well suited to such crops as corn, soybeans, grain sorghum, and wheat. It is also suited to legumes, grasses, and trees. Capability unit IIe–1; Silty range site; Silty to Clayey windbreak group.

Monona silt loam, 5 to 12 percent slopes (MnC).—This soil occupies broad, irregularly shaped tracts on valley sides below ridgetops.

This soil has the profile described as typical for the Monona series. Included in mapping were small tracts of Geary silty clay loam, 5 to 12 percent slopes, eroded, and Monona silt loam, 5 to 12 percent slopes, eroded.

Tilth is good, permeability is moderate, and available water capacity is high. Surface runoff is medium to rapid. The severe erosion hazard is the main concern.

Most of the acreage is cultivated. This soil is well suited to cultivated crops if erosion control measures are used. It is also suited to grasses and trees. Capability unit IIIe–1; Silty range site; Silty to Clayey windbreak group.

Monona silt loam, 5 to 12 percent slopes, eroded (MnC2).—This soil is in medium to large, irregularly shaped tracts on valley sides near drainageways.

This soil has a profile similar to the one described as typical for the Monona series, but the surface layer is thinner and lighter colored. Most of the original surface layer has been removed by water erosion. The present surface layer is 5 to 8 inches thick and dark yellowish brown. It is a mixture of what is left of the original surface layer and material from the upper part of the subsoil. Included in mapping were some areas of Ida soils and few to many small areas of eroded, grayish soils that are moderately low in phosphorus.

This soil is responsive to good management because permeability is moderate and available water capacity is high. The organic-matter content is moderately low. Runoff is rapid. Unless protected, this soil is subject to further erosion. Controlling erosion and increasing fertility are the main concerns.

Most of the acreage is cultivated, but some areas are used for pasture. This soil is suited to all crops commonly grown in the county. It is also suited to grasses and trees. Capability unit IIIe–8; Silty range site; Silty to Clayey windbreak group.

Figure 6.—**Profile of Monona silt loam showing weak blocky structure in subsoil. The soil is only about 30 inches thick.**

Monona silt loam, 12 to 17 percent slopes (MnD).—This soil is in a few irregularly shaped tracts on hillsides near small drainageways. It has a profile similar to the one described as typical of the series, but the subsoil is slightly thinner.

Included in mapping were a few small areas of Geary and Ida soils.

Permeability is moderate, and available water capacity is high. In cultivated areas runoff is rapid, and the hazard of erosion is severe. Control of erosion is a necessary part of good management. Farm machinery is difficult to operate on this moderately steep soil.

About half the acreage is cultivated, and the other half is in pasture. This soil is not well suited to continuous row cropping. It is best suited to wheat, clover, grain sorghum, and alfalfa. It is well suited to hay, pasture, range, and wildlife. Capability unit IVe–1; Silty range site; Silty to Clayey windbreak group.

Monona silt loam, 12 to 17 percent slopes, eroded (MnD2).—This soil is in medium to large, irregularly shaped tracts on hillsides near small drainageways.

This soil has a profile similar to the one described as typical for the Monona series, but the surface layer is thinner and lighter colored as a result of water erosion. The present surface layer is 5 to 8 inches thick and dark yellowish brown. It is a mixture of what is left of the original surface layer and material from the upper part of the subsoil. Included in mapping were small areas of Ida silt loam, 12 to 17 percent slopes, eroded; and areas of an eroded, grayish soil moderately low in phosphorus.

The organic-matter content is moderately low, runoff is rapid, and the hazard of erosion is severe. The main concerns in management are controlling erosion and increasing fertility. Farm machinery is difficult to operate on this moderately steep soil.

This soil is best suited to wheat, clover, and alfalfa and is well suited to hay, pasture, and range. It is not well suited to continuous row cropping. Capability unit IVe–8; Silty range site; Silty to Clayey windbreak group.

Monona silt loam, 17 to 30 percent slopes (MnF).—This steep soil is on hillsides and sides of drainageways leading to the bottom land along the Missouri River.

About 65 percent of the acreage has slopes of 25 to 30 percent and a cover of grasses and deciduous trees. About 35 percent of the acreage has slopes of 17 to 25 percent and is eroded.

This soil has a profile similar to the one described as typical for the Monona series, but in the eroded areas is lighter colored. Included in mapping were small tracts of Rough broken land and Ida silt loam, 17 to 30 percent slopes.

Runoff is rapid or very rapid, and the erosion hazard is severe. Erosion control is a serious concern in management. Slopes are too steep for continuous tillage. Establishing, improving, and maintaining a permanent cover of vegetation are other concerns in management.

About three-fourths of the acreage is pasture. This soil is suited to hay, pasture, range, and wildlife. Capability unit VIe–1; Silty range site; Silty to Clayey windbreak group.

Morrill Series

The Morrill series consists of deep, well-drained, sloping to moderately steep soils that formed in yellowish-red, brown, and reddish-brown material reworked from glacial deposits. These soils are on the uplands.

In a typical profile, the surface layer is very dark grayish-brown clay loam about 6 inches thick. The subsoil is about 39 inches thick. The upper 4 inches is dark reddish-brown friable clay loam; the next 27 inches is dark reddish-brown and reddish-brown firm clay loam; and the lower 8 inches is reddish-brown, friable light clay loam. The lower part of the subsoil is gritty. The underlying material, to a depth of 60 inches, is yellowish-red coarse loam.

Morrill soils have moderately slow to moderate permeability and high available water capacity. They are medium to high in natural fertility. They are slightly acid or medium acid throughout the profile. They are susceptible to erosion.

Most of the acreage is cultivated, but some areas, especially the steeper slopes, are used for grass. A few small areas are being used as a source of sand and gravel.

Typical profile of Morrill clay loam, in an area of Morrill soils, 5 to 12 percent slopes, eroded, 0.13 mile west and 180 feet south of the northeast corner of sec. 21, T. 3 N., R. 13 E.:

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, blocky structure parting to weak, medium, granular; friable when moist, hard when dry; slightly acid; abrupt, smooth boundary.

B1—6 to 10 inches, dark reddish-brown (5YR 3/3) clay loam, brown (7.5YR 4/2) when dry; weak, medium, subangular blocky structure parting to weak, fine and very fine, subangular blocky; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

B21t—10 to 25 inches, dark reddish-brown (5YR 3/4) and reddish-brown (5YR 4/4) clay loam, reddish brown (5YR 4/3) when dry; weak, coarse, blocky structure parting to weak, medium and fine, subangular blocky; firm to friable when moist, hard when dry; shiny surfaces on peds; slightly acid; gradual, smooth boundary.

B22t—25 to 37 inches, reddish-brown (5YR 4/4) clay loam, reddish brown (5YR 5/4) when dry; weak, coarse, blocky structure parting to weak, medium, subangular blocky; firm to friable when moist, hard when dry; thin, shiny surfaces on faces of peds; soil contains enough sand to have a gritty feel; slightly acid; gradual, smooth boundary.

B3—37 to 45 inches, reddish-brown (5YR 4/4) coarse clay loam, reddish brown (5YR 5/4) when dry; weak, coarse, blocky structure; friable when moist, hard when dry; soil contains enough sand to have a gritty feel; slightly acid; gradual, smooth boundary.

C—45 to 60 inches, yellowish-red (5YR 4/6) coarse loam, reddish brown (5YR 5/4) when dry; massive; friable when moist, hard when dry; more coarse sand and pebbles than in the upper horizons; slightly acid.

In areas of native sod, the A horizon is as much as 12 inches thick. The upper part is black or very dark brown loam, but in some places it is sandy loam. Reaction ranges from medium acid to slightly acid throughout the profile. In some places thin clayey strata or coarse sand occurs at a depth below 40 inches.

In mapping unit MC3 the soils have a lighter colored and thinner A horizon than is defined in the range for the series, but these differences do not alter the usefulness of the soils.

Morrill soils are in the same general areas as Pawnee and Mayberry soils. They have a redder B horizon and less clay than Pawnee soils. They are similar in color, but have less clay in the B horizon than Mayberry soils. They are similar in color, but have more grit throughout the profile than Geary soils.

Morrill soils, 5 to 12 percent slopes, eroded (MC2).—These soils occupy irregularly shaped tracts on valley sides near drainageways. They formed in sediment that contains various amounts of grit.

These soils have a profile similar to the one described as typical for the Morrill series, but the surface layer is clay loam, loam, gritty loam, gravelly loam (fig. 7), sandy loam, or silty clay loam. Included in mapping were areas of soils that have a sandy loam or loam subsoil, and a few areas of soils that have a coarse sand or gravelly layer in the lower subsoil. Also included were areas of Pawnee, Mayberry, and Geary soils, and small sand and gravel pits.

These soils are easy to till. Permeability is mostly moderately slow to moderate, and available water capacity is mostly high. Runoff is medium to rapid. The erosion hazard is severe. Controlling erosion is the main concern of management.

Most of the acreage is cultivated. A few acres are pasture. These soils are suited to all cultivated crops commonly grown in the county. They are also suited to grasses and trees. Capability unit IIIe–1; Silty range site; Silty to Clayey windbreak group.

Morrill soils, 5 to 12 percent slopes, severely eroded (MC3).—These soils are in small, irregularly shaped tracts on valley sides near drainageways.

These soils have a profile similar to the one described as typical for the Morrill series, but are less dark and have a surface layer of gritty loam, gravelly loam, sandy loam, or silty clay loam. Much of the original surface layer has been removed by erosion. The upper part of the subsoil has been exposed and is now the main part of the present surface layer. Included in mapping were areas of soils that have a sandy subsoil and of soils that have gravelly layers. Also included were areas of Pawnee, Mayberry, and Geary soils and a few small sand and gravel pits.

The organic-matter content is moderately low. Runoff is rapid. Unless protected, the soils are subject to further erosion. Controlling erosion and increasing fertility are the main concerns.

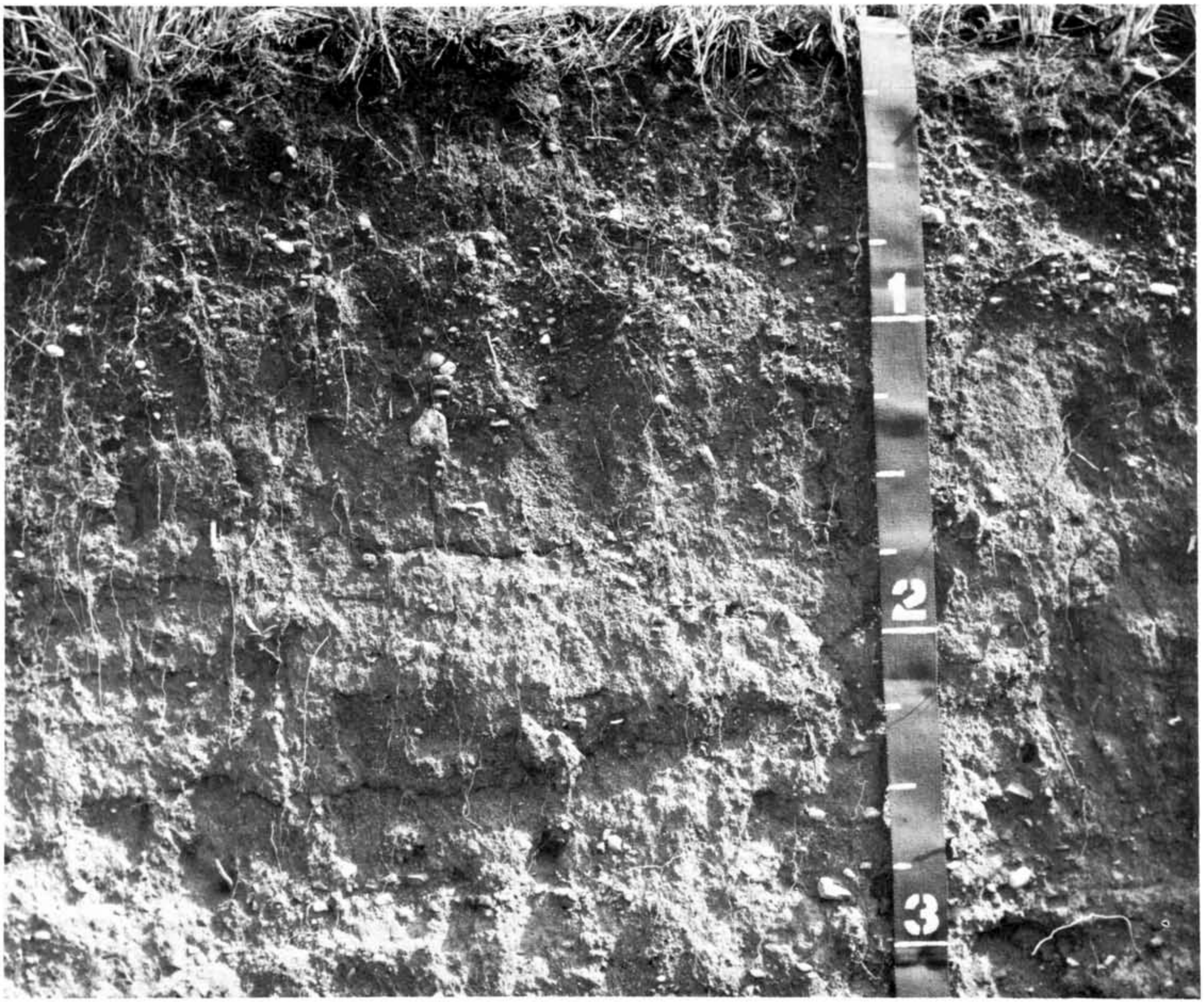

Figure 7.—Profile of a Morrill soil showing gritty loam surface layer about 12 inches thick, gritty clay loam subsoil about 24 inches thick, and coarse sand and gravel below a depth of 3 feet.

These soils are not well suited to continuous row crops. They are suited to wheat, grain sorghum, clover, and alfalfa and to a limited amount of soybeans and corn. They are well suited to hay, pasture, range, and wildlife. Capability unit IVe–8; Silty range site; Silty to Clayey windbreak group.

Morrill soils, 12 to 17 percent slopes (MD).—These moderately steep soils are on a few valley sides near drainageways.

These soils have a profile similar to the one described as typical for the Morrill series, but the surface layer is clay loam, gritty loam, or sandy loam. Included in mapping were areas of soils that have a sandy subsoil; areas of soils that have gravelly layers; areas of Kipson-Sogn complex, 3 to 30 percent slopes, and areas where glacial boulders are on the surface.

Runoff is rapid. Where these soils are cultivated, the erosion hazard is severe. Controlling erosion is a necessary part of good management. Farm machinery is difficult to operate on these moderately steep soils.

Most of the acreage is in grass. These soils are well suited to wheat, legumes, hay, pasture, and range. Row crops are grown to prepare a seedbed for grasses, legumes, or windbreak plantings. Capability unit IVe–1; Silty range site; Silty to Clayey windbreak group.

Nodaway Series

The Nodaway series consists of deep, well-drained, nearly level soils that formed in silty alluvium. These soils are on bottom land along the Nemaha River and on fans deposited at the mouths of small drainageways.

In a typical profile, the surface layer is very dark grayish-brown silt loam about 7 inches thick. The underlying material consists of stratified, dark grayish-brown and grayish-brown, very friable silt loam and very fine sandy loam and thin strata of very dark grayish-brown silty clay loam.

Nodaway soils have moderate permeability and high available water capacity. They are neutral in reaction throughout the profile. They are high in natural fertility and have good tilth.

Nearly all the acreage is cultivated. A few odd-shaped tracts are used for grassland, and a few for wildlife. Some deciduous trees are along the edges of old stream channels.

Typical profile of Nodaway silt loam, 0.2 mile north and 200 feet west of the southeast corner of sec. 32, T. 1 N., R. 18 E.:

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) when moist; weak, coarse and medium, blocky structure parting to weak, very fine, granular; very friable when moist, soft when dry; neutral; abrupt, smooth boundary.

C—7 to 60 inches, stratified, dark grayish-brown (10YR 4/2) silt loam, grayish-brown (10YR 5/2) very fine sandy loam, and thin strata of very dark grayish-brown (10YR 3/2) silty clay loam; light brownish gray (10YR 6/2), light gray (10YR 7/2), and grayish brown (10YR 5/2) when moist; compound, weak, medium, blocky structure and weak, medium and coarse, platy structure; very friable when moist, soft when dry; neutral.

In places, black, very dark brown, or very dark grayish-brown buried soils of silty clay loam texture are below a depth of 36 inches.

Nodaway soils are in the same general areas as the Hobbs soils. They are more stratified and have a thinner, lighter colored A horizon than Hobbs soils. They are similar to Haynie soils, but they are not limy.

Nodaway silt loam (0 to 1 percent slopes) (Nd).—This soil is mainly on bottom land near the Nemaha River. It is protected from overflow by dikes.

This soil is well drained and easy to work. If well managed, it can be farmed intensively without risk of damage. Fertility is easy to maintain. Organic-matter content is moderate.

Most of the acreage is cultivated. All crops commonly grown in the country are suitable. Corn, soybeans, and grain sorghum are the principal crops. Capability unit I–1; Silty Lowland range site; Silty to Clayey windbreak group.

Onawa Series

The Onawa series consists of deep, somewhat poorly drained, nearly level soils that formed in clayey and silty alluvium. These soils are on the bottom land along the Missouri River.

In a typical profile, the surface layer is very dark gray silty clay about 7 inches thick. The first 11 inches of the underlying material is olive-gray very firm silty clay; the next 9 inches is dark grayish-brown, very firm light silty clay; and this is followed by 23 inches of stratified, dark grayish-brown and grayish-brown, friable silt loam, very fine sandy loam, and silty clay loam.

Onawa soils have poor drainage because runoff is slow and permeability is slow in the upper part of the profile. They are high in available water capacity and natural fertility. They are mildly alkaline to moderately alkaline throughout the profile. Poor tilth and wetness are limitations.

Most of the acreage is cultivated.

Typical profile of Onawa silty clay, 0.15 mile north and 100 feet east of the southwest corner of the NW¼ sec. 28, T. 1 N., R. 18 E.:

Ap—0 to 7 inches, very dark gray (5Y 3/1) silty clay, dark gray (5Y 4/1) when dry; weak, coarse, blocky structure parting to weak, fine angular blocky; very firm when moist, very hard when dry; calcareous; mildly alkaline; clear, smooth boundary.

C1g—7 to 18 inches, olive-gray (5Y 4/2) silty clay, gray (5Y 5/1) when dry; weak, coarse, blocky structure parting to weak, medium, angular blocky; very firm when moist, very hard when dry; few, faint, very fine, olive-brown mottles; calcareous; mildly alkaline; gradual, smooth boundary.

C2g—18 to 27 inches, dark grayish-brown (2.5Y 4/2) light silty clay, grayish brown (2.5Y 5/2) when dry; weak, medium and fine, angular blocky structure; very firm when moist, very hard when dry; common, distinct, olive-brown mottles; calcareous; mildly alkaline; clear, smooth boundary.

IIC3g—27 to 50 inches, stratified, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) silt loam, very fine sandy loam, and silty clay loam, light brownish gray (2.5Y 6/2) and light gray (2.5Y 7/2) when dry; weak, coarse, blocky structure parting to weak, very coarse, platy; friable when moist, slightly hard when dry; many, diffuse, dark yellowish-brown mottles; calcareous; moderately alkaline.

The combined thickness of the Ap, C1g, and C2g horizons ranges from 18 to 30 inches. In some places the A horizon is silty clay loam.

Onawa soils are in the same general areas as Albaton soils. In contrast with Albaton soils, they are silty clay to a depth of 18 to 30 inches, whereas Albaton soils are silty clay to a depth of 40 inches or more.

Onawa silty clay (0 to 1 percent slopes) (Oc).—This soil occupies a few broad tracts on bottom land of the Missouri River Valley.

Included in mapping were small tracts of Haynie and Albaton soils.

Because of the clayey surface layer and slow runoff, good tilth and wetness are limitations. This soil dries slowly in spring and stays wet during periods of above normal rainfall.

Most of the acreage is cultivated. This soil is best suited to such crops as grain sorghum, soybeans, wheat, alfalfa, and red clover. Corn can be grown if the soil is adequately drained and the weather is favorable. This soil is also suited to hay and wildlife. Capability unit IIIw–1; Clayey Overflow range site; Moderately Wet windbreak group.

Pawnee Series

The Pawnee series consists of deep, moderately well drained, gently sloping to strongly sloping soils that formed in very firm glacial material. These soils are on uplands.

In a typical profile, the surface layer is very dark brown light clay loam about 7 inches thick. The subsoil is about 30 inches thick (fig. 8). The upper 4 inches is very dark grayish-brown, friable clay loam; the next 14 inches is brown, very firm clay; the next 5 inches is olive-brown, very firm clay; and the lower 7 inches is light olive-brown, very firm clay. The underlying material is light olive-brown heavy clay loam.

Pawnee soils have slow permeability and are moderate in available water capacity. They are medium to high in natural fertility. They are slightly acid or medium acid in the surface layer and upper part of the subsoil, slightly acid or neutral in the middle part of the subsoil, and mildly alkaline in the lower part of the subsoil. They are susceptible to erosion.

Most of the acreage is cultivated. Some areas are in tame grass or native range.

Typical profile of Pawnee clay loam, in an area of Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded, 0.3 mile south and 320 feet west of the northeast corner of sec. 24, T. 2 N., R. 14 E.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) light clay loam, dark grayish brown (10YR 4/2) when dry; weak, coarse, blocky structure parting to weak, fine, granular; friable when moist, hard when dry; slightly acid; abrupt, smooth boundary.

B1—7 to 11 inches, very dark grayish-brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) when dry; weak, coarse, blocky structure parting to moderate, fine, subangular blocky; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

B21t—11 to 25 inches, brown (10YR 4/3) clay, yellowish brown (10YR 5/4) when dry; moderate, medium, angular blocky structure; very firm when moist, extremely hard when dry; few, distinct, dark accumulations (iron or manganese oxides); some dark organic coatings on faces of peds; shiny surfaces on peds; neutral; gradual, smooth boundary.

B22t—25 to 30 inches, olive-brown (2.5Y 4/4) clay, light olive brown (2.5Y 5/4) when dry; moderate, coarse and medium, angular blocky structure; very firm when moist, extremely hard when dry; common, fine, strong-brown mottles; common, distinct, dark accumulations (iron or manganese oxides); few dark organic coatings; shiny surfaces on peds; neutral; gradual, smooth boundary.

B3t—30 to 37 inches, light olive-brown (2.5Y 5/4) clay, light yellowish brown (2.5Y 6/4) when dry; moderate, medium, angular blocky structure; very firm when moist, extremely hard when dry; common, medium, distinct, strong-brown mottles; few, distinct, dark accumulations (iron or manganese oxides); shiny surfaces on peds; thin lime deposits coat faces of some pebbles; mildly alkaline; gradual, smooth boundary.

C—37 to 50 inches, light olive-brown (2.5Y 5/4) heavy clay loam, light yellowish brown (2.5Y 6/4) when dry; weak, coarse, blocky structure; very firm when moist, very hard when dry; few, fine, gray mottles and common, medium, distinct, strong-brown mottles; many, large, dark accumulations (iron or manganese oxides); few pieces of weathered shale; few, large lime concretions; mildly alkaline.

In areas of native sod the A horizon is up to 16 inches thick, and the upper 6 to 8 inches is loam. The Ap horizon ranges from 5 to 9 inches in thickness. The Ap and B1 horizons range from medium acid to slightly acid; the B21t horizon ranges from slightly acid to neutral. In places, there is no B1 horizon. In places, the B21t horizon contains grayish-

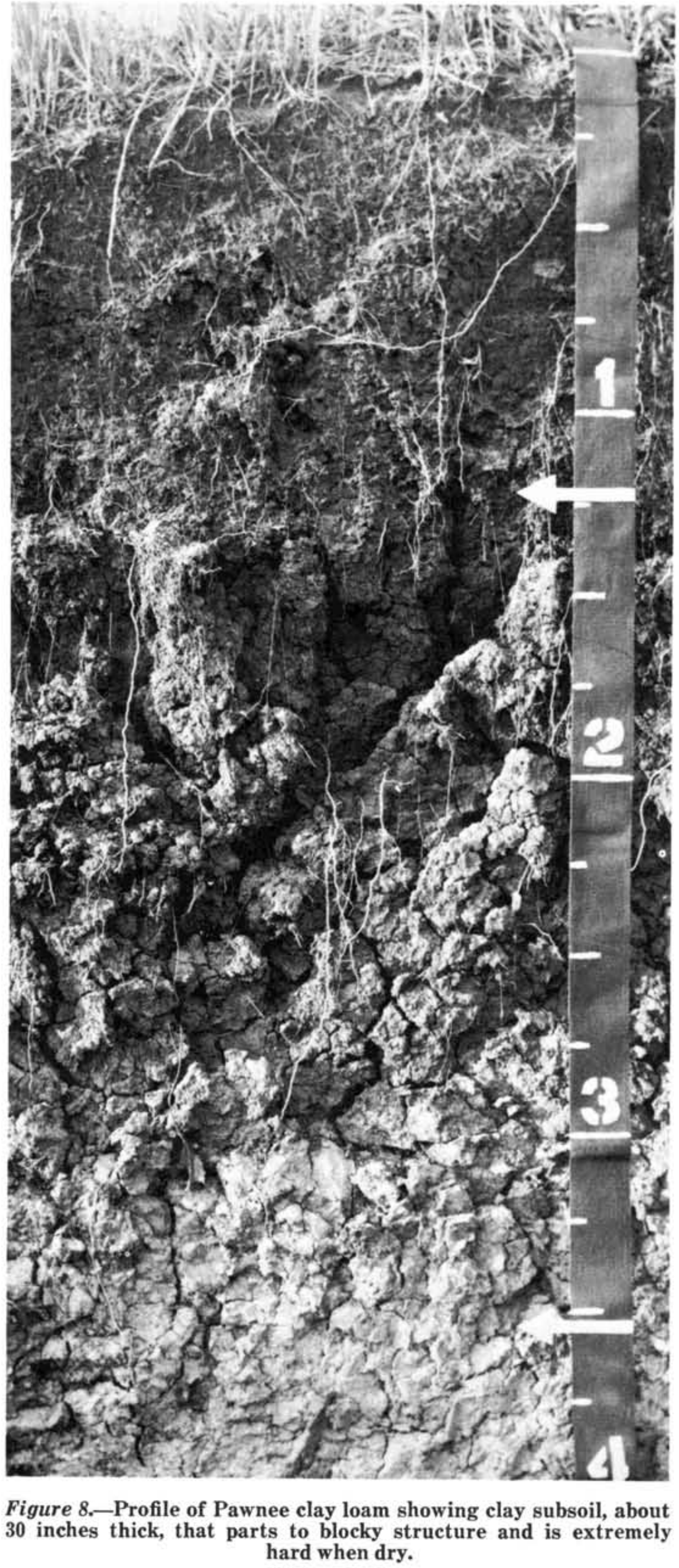

***Figure 8.*—Profile of Pawnee clay loam showing clay subsoil, about 30 inches thick, that parts to blocky structure and is extremely hard when dry.**

brown to reddish-brown mottles. Depth to the C horizon ranges from 36 to 55 inches. In places, the C horizon is calcareous and contains both concretionary and disseminated lime.

The Pawnee soils in mapping unit PAD3 have a thinner, lighter colored A horizon than is defined in the range for the series, but these differences do not alter the usefulness of the soil.

Pawnee soils are in the same general areas as the Mayberry, Morrill, and Wymore soils. They have a clay B horizon similar to Mayberry soils, but it is less red. They have a more clayey, but less red B horizon than Morrill soils. They contain more grit throughout the profile than Wymore soils, which formed in loess.

Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded (PAC2).—These soils occupy many, small to medium, irregularly shaped tracts mainly on valley sides near drainageways.

Included in mapping were small areas of sand and gravel and small tracts of Morrill soils.

The available water capacity is moderate, permeability is slow, and runoff is rapid. The erosion hazard is severe. The main concern of management is controlling erosion and conserving water.

These soils are best suited to such drought-resistant and close-growing crops as grain sorghum, wheat, and clover. In years of favorable moisture corn and soybeans can be grown in rotation with these crops. These soils are also suited to hay, pasture, range, and windbreak plantings. About one-fourth of the acreage is in grass. Capability unit IIIe-2; Clayey range site; Silty to Clayey windbreak group.

Pawnee and Mayberry clay loams, 9 to 12 percent slopes, eroded (PAD2).—These strongly sloping soils occupy a few small tracts on valley sides near drainageways. Each soil has a profile similar to the one described as typical of the series, but the subsoil is slightly thinner. Included in mapping were small areas of sand and gravel and small areas of Morrill soils.

Available water capacity is moderate, permeability is slow, and runoff is rapid. The erosion hazard is very severe. The main concerns of management are controlling erosion and conserving moisture. Farm machinery is difficult to operate and grassed waterways are difficult to maintain on these strongly sloping soils.

Most of the acreage is in grass. These soils are best suited to small grain, grain sorghum and legumes. They are well suited to hay, pasture, and range. Capability unit IVe-2; Clayey range site; Silty to Clayey windbreak group.

Pawnee and Mayberry clay loams, 3 to 12 percent slopes, severely eroded (PAD3).—These soils occupy irregularly shaped tracts mainly on hillsides near small drainageways. Each has a profile similar to that described as typical for its respective series, but the surface layer is lighter colored. Also, much of the original surface layer has been removed by erosion, and the subsoil is now near the surface. In places the surface layer is clay and is locally referred to as "gumbo."

Included in mapping were small areas of severely eroded Morrill and Wymore soils.

Tilth is poor, organic-matter content is moderately low, and permeability is slow. Runoff is rapid, and the erosion hazard is severe. The concerns of management are controlling erosion, conserving of water, improving tilth, and increasing fertility.

These soils are not well suited to cultivated crops. Such close-growing crops as wheat and legumes are best suited. Grain sorghum is the best suited row crop. In places these soils are within larger tracts of a soil that is better suited to cultivation. In these places additions of manure or fertilizers are beneficial on the small tracts.

These soils are used for hay, pasture, or range, to which they are well suited. They are also suited to windbreak plantings and wildlife. Capability unit IVe-4; Dense Clay range site; Silty to Clayey windbreak group.

Rough Broken Land

Rough broken land (31 to 65 percent slopes) (RB) is on very steep hills and bluffs near the bottom land along the Missouri River Valley. The soil material is mostly silt loam loess. Slopes break abruptly to many small drainageways. In places there are outcrops of limestone, sandstone, and shale at the lower elevations.

Included in mapping were areas of Monona silt loam, 17 to 30 percent slopes, and Ida silt loam, 17 to 30 percent slopes, eroded.

Runoff is very rapid. The erosion hazard is very severe. Slopes are too steep for any tillage. Controlling erosion is a serious concern in management. Restoring and maintaining plants for permanent cover are a necessary part of good management.

This land is suited to perennial grasses and trees. Most areas have a cover of trees and shrubs. In places there is a understory of grass on the higher and more exposed slopes. Capability unit VIIe-1; Savannah range site; Undesirable windbreak group.

Sarpy Series

The Sarpy series consists of deep, excessively drained, nearly level to very gently undulating soils that formed in sandy alluvium. These soils are on the bottom land along the Missouri River.

In a typical profile, the surface layer is dark-brown loamy fine sand about 8 inches thick. The underlying material, to a depth of 50 inches, is loose loamy fine sand. The upper part is dark grayish brown, and the lower part is grayish brown.

Sarpy soils have rapid permeability and low available water capacity. They are low to medium in natural fertility. They are mildly alkaline throughout the profile.

Sarpy soils are used for crops, grasses, and wildlife. Uncleared areas have a dense to sparse cover of young deciduous trees and a variable understory of grasses.

Typical profile of Sarpy loamy fine sand, 0.1 mile east and 200 feet south of the northwest corner of sec. 31, T. 1 N., R. 19 E.:

Ap—0 to 8 inches, dark-brown (10YR 4/3) loamy fine sand, pale brown (10YR 6/3) when dry; single grain; loose when moist, loose when dry; mildly alkaline; gradual, smooth boundary.

C1—8 to 30 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (10YR 6/2) when dry; single grain; loose when moist, loose when dry; few, very thin strata of very fine sand; mildly alkaline, calcareous; clear, smooth boundary.

C2—30 to 50 inches, grayish-brown (10YR 5/2) loamy fine sand, light gray (10YR 7/2) when dry; single grain; loose when moist, loose when dry; mildly alkaline, calcareous.

In undisturbed areas, the A horizon ranges from 1 to 6 inches in thickness, is very dark grayish brown in color, and neutral in reaction. The A horizon ranges from fine sandy loam to fine sand. The C horizon is loamy fine sand or fine sand. In places loamy textures occur at depths below 40 inches.

Sarpy soils are in the same general areas as the Haynie soils. They have a loamy fine sand or sand texture, but Haynie soils have a silt loam and very fine sandy loam texture throughout the profile.

Sarpy loamy fine sand (0 to 2 percent slopes) (Sg).—This soil occupies a few tracts on the bottom land of the Missouri River Valley.

The organic-matter content and available water capacity are low. The main concern of management is conserving moisture. Controlling soil blowing and maintaining fertility are secondary concerns.

This soil is best suited to alfalfa, clover, wheat, and grain sorghum. Soybeans are grown on small tracts. This soil is also suited to grasses, windbreak plantings, and wildlife. Capability unit IVs-5; Sandy Lowland range site; Sandy windbreak group.

Sharpsburg Series

The Sharpsburg series consists of deep, moderately well drained, nearly level to strongly sloping soils that formed in light yellowish-brown loess. These soils are on the uplands, mainly in an area 4 to 7 miles wide, parallel and adjacent to the Marshall and Monona soils.

In the typical profile, the surface layer is very dark brown silty clay loam about 10 inches thick. The subsoil is about 30 inches thick (fig. 9). The upper 5 inches is dark-brown, firm heavy silty clay loam; the next 5 inches is dark yellowish-brown, firm heavy silty clay loam; the next 10 inches is brown, firm heavy silty clay loam; and the lower 10 inches is yellowish-brown, friable silty clay loam. The underlying material is light yellowish-brown light silty clay loam.

Sharpsburg soils have moderately slow permeability and high available water capacity. They are high in natural fertility and are slightly acid or medium acid throughout the profile.

Nearly all of the acreage is used for crops. These soils are also suited to grasses, windbreaks, and wildlife.

Typical profile of Sharpsburg silty clay loam, 2 to 5 percent slopes, eroded, 0.2 mile north and 100 feet west of the southeast corner of sec. 8, T. 2 N., R. 15 E.:

Ap—0 to 10 inches, very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky and weak, coarse, blocky structure parting to weak, fine, granular; friable when moist, hard when dry; medium acid; gradual, smooth boundary.

B21t—10 to 15 inches, dark-brown (10YR 3/3) heavy silty clay loam, dark grayish brown (10YR 4/2) when dry; weak, medium, prismatic structure parting to weak, fine, subangular blocky; firm when moist, hard when dry; shiny surfaces on peds; medium acid; gradual, smooth boundary.

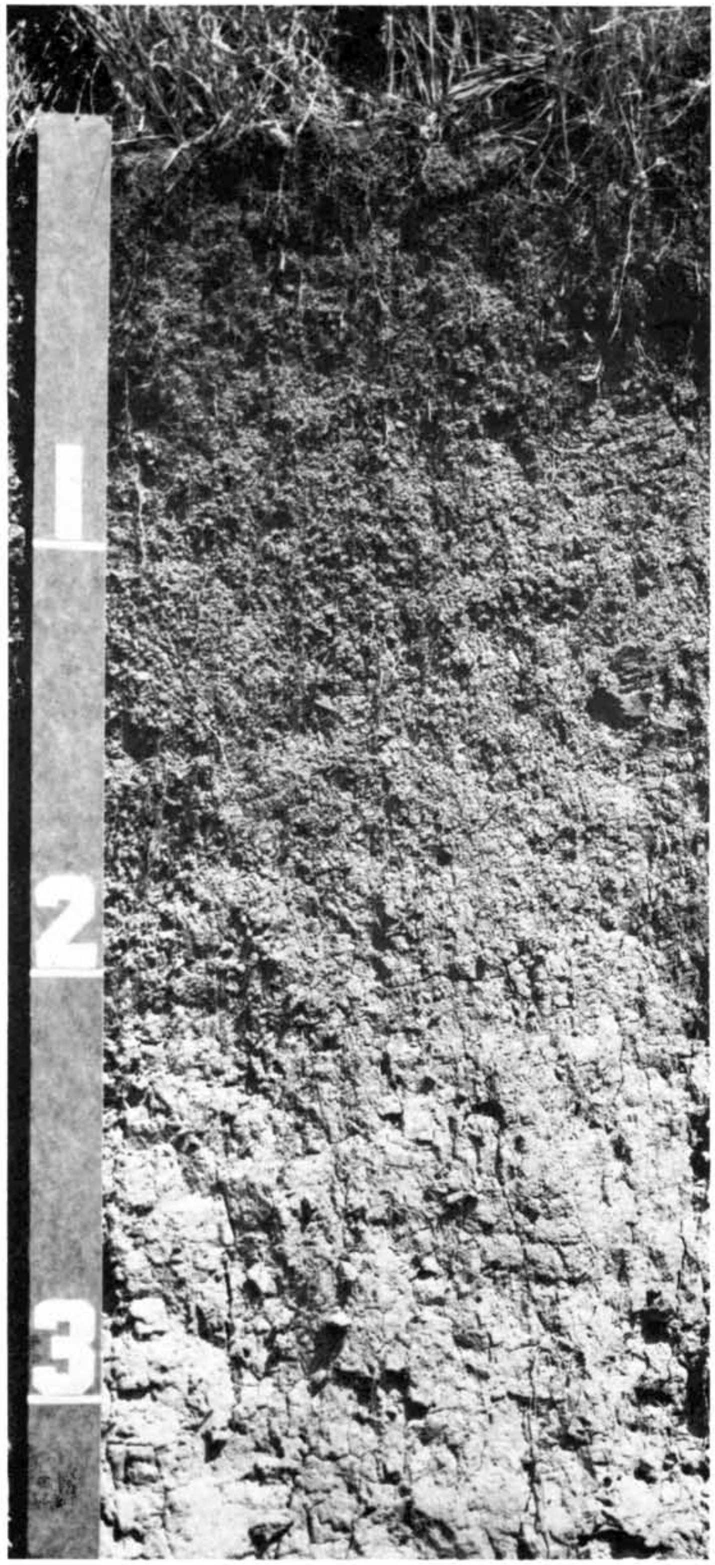

Figure 9.—Profile of Sharpsburg silty clay loam showing 10-inch, dark-colored surface layer, fine blocky structure in subsoil to a depth of about 28 inches, and coarse and medium blocky structure below a depth of 28 inches.

B22t—15 to 20 inches, dark yellowish-brown (10YR 3/4) heavy silty clay loam, brown (10YR 5/3) when dry; weak, coarse, prismatic structure parting to moderate, fine and medium, subangular blocky; firm when moist, very hard when dry; shiny surfaces on peds; medium acid; gradual, smooth boundary.

B23t—20 to 30 inches, brown (10YR 4/3) heavy silty clay loam, pale brown (10YR 6/3) when dry; weak, coarse, prismatic structure parting to moderate, medium, blocky; firm when moist, hard when dry; few, fine, dark accumulations (iron or manganese oxides); few, fine, gray mottles; slightly acid; gradual, smooth boundary.

B3t—30 to 40 inches, yellowish-brown (10YR 5/4) silty clay loam, very pale brown (10YR 7/4) when dry; weak, coarse, prismatic structure parting to weak, medium, blocky; friable when moist, hard when dry; fine, dark accumulations (iron or manganese oxides); shiny surfaces on peds; common, medium, strong-brown and gray mottles; slightly acid; gradual, smooth boundary.

C—40 to 60 inches, light yellowish-brown (10YR 6/4) light silty clay loam, very pale brown (10YR 7/3) when dry; weak, coarse, prismatic structure; friable when moist, hard when dry; many, fine, dark accumulations (iron or manganese oxides); common, medium, distinct, gray mottles; slightly acid.

The A1 horizon in areas of native sod ranges from 10 to 18 inches in thickness. The B2t horizon ranges from 20 to 32 inches in thickness. In some places, the C horizon is grayish brown or light brownish gray instead of light yellowish brown or pale brown.

The Sharpsburg soil in mapping unit ShC3 has a thinner, lighter colored A horizon than is defined for the series, but these differences do not alter its use.

Sharpsburg soils are in the same general areas as Marshall, Wymore, and Geary soils. They have more clay in the B horizon than Marshall soils that adjoin to the east. They have less clay in the B horizon than Wymore soils that adjoin to the west. They are similar in texture to Geary soils, but the Geary soils formed in Loveland loess and have a redder B horizon.

Sharpsburg silty clay loam, 0 to 2 percent slopes (ShA).—This soil occupies a few, broad, very gently sloping tracts on upland divides.

This soil has a profile similar to the one described as typical for the series, but the surface layer is thicker. This soil is easy to work and manage. Permeability is moderately slow, and available water capacity is high. Under good management it can be cultivated intensively without risk of damage.

Most of the acreage is used for grain sorghum, corn, soybeans, and wheat. This soil is also suited to clover, alfalfa, grasses, and trees. Capability unit I–1; Silty range site; Silty to Clayey windbreak group.

Sharpsburg silty clay loam, 2 to 5 percent slopes, eroded (ShB2).—This soil occupies irregularly shaped, narrow to broad ridgetops. It has the profile described as typical for the Sharpsburg series.

Tilth is good, permeability is moderately slow, and available water capacity is high. Runoff is medium. Controlling erosion is a slight concern in management.

Most of the acreage is cultivated. This soil is suited to all crops commonly grown in the county. It is also suited to grasses and windbreak plantings. Capability unit IIe–1; Silty range site; Silty to Clayey windbreak group.

Sharpsburg silty clay loam, 5 to 12 percent slopes, eroded (ShC2).—This soil has smooth slopes. It occupies broad, irregularly shaped tracts on valley sides below ridgetops. It has a profile similar to the one described as typical of the series, but the subsoil is slightly thinner.

Included in mapping were small tracts of Geary silty clay loam, 5 to 12 percent slopes, eroded, and areas of severely eroded Sharpsburg soils.

Available water capacity is high, and permeability is moderately slow. Runoff is medium to rapid, and the erosion hazard is severe. Erosion is the main concern in management. Maintaining good tilth is a minor concern.

Nearly all the acreage is cultivated. This soil is suited to grain sorghum, corn, soybeans, wheat, clover, and alfalfa. It is also suited to pasture and windbreak plantings. Capability unit IIIe–1; Silty range site; Silty to Clayey windbreak group.

Sharpsburg silty clay loam, 3 to 12 percent slopes, severely eroded (ShC3).—This soil occupies small to medium sized, irregularly shaped tracts that occur intermittently on hillsides near drainageways.

This soil has a profile similar to the one described as typical for the Sharpsburg series, but the surface layer is thinner and lighter colored, and in places the subsoil is exposed. The present surface layer is 5 to 8 inches thick and is dark brown or brown. It has been mixed with material from the upper part of the subsoil. Included in mapping were small areas of severely eroded Geary and Morrill soils and some areas of Sharpsburg silty clay loam, 5 to 12 percent slopes, eroded.

This soil responds to good management. The organic-matter content is moderately low, permeability is moderately slow, and the available water capacity is high. Runoff is rapid. The erosion hazard is severe. Controlling erosion and maintaining fertility are the main concerns of management. Maintaining good tilth is a minor concern.

Most of the acreage is cultivated. This soil is suited to all crops commonly grown in the county. It is also suited to grasses and trees. Capability unit IIIe–8; Silty range site; Silty to Clayey windbreak group.

Silty Alluvial Land

Silty alluvial land (0 to 1 percent slopes) (Sy) occupies narrow tracts on flood plains adjacent to meandering streams. It is layered and subject to change each time the streams overflow. Mainly it is grayish-brown to very dark brown silt loam, loam, very fine sandy loam, and silty clay loam. In places sandy or clayey sediment is present.

The flood hazard is severe. Crooked stream channels dissect the areas and make cultivation impractical. Restoring and maintaining permanent plants are a necessary part of good management.

Silty alluvial land is suited to grasses, windbreak plantings, woodland, and wildlife. The vegetation consists of trees, shrubs, annual weeds, and grasses. Capability unit VIw–1; Silty Overflow range site; Moderately Wet windbreak group.

Slickspots

Slickspots are nearly level, irregularly shaped areas or patches of alkali soil on bottom land. They have alkali and clay near the surface. They are slick when wet and extremely hard when dry.

Slickspots-Wabash complex (0 to 1 percent slopes) (SZ).—This complex occupies small to large tracts on the bottom lands along the Nemaha River and Muddy Creek. About 60 percent is Slickspots, and about 40 percent

Wabash silty clay and Wabash silty clay loam. Slickspots have a surface layer of very dark gray silty clay or silty clay loam that ranges from 8 to 30 inches in thickness, is mildly to very strongly alkaline, and in places contains salts and disseminated lime. Generally, a thin white crust forms on the surface when the soil is dry. The underlying material is very dark gray very firm silty clay. It is strongly to very strongly alkaline and contains salts and lime concentrations.

These soils have poor tilth and are difficult to work. They have very slow or slow permeability and low or moderate available water capacity. The main concerns of management are improving tilth and drainage and conserving water.

These soils are best suited to wheat, grain sorghum, and alfalfa. They are also suited to grasses and trees. Capability unit IVs-1; Clayey Overflow range site; Moderately Saline or Alkali windbreak group.

Sogn Series

The Sogn series consists of shallow, somewhat excessively drained, gently sloping to steep soils that formed in material weathered from hard limestone (fig. 10). These soils are on uplands, mainly along tributaries to the Nemaha River.

In a typical profile, the surface layer is very dark brown silty clay loam about 8 inches thick. Fragments of limestone are commonly on the surface. The underlying material extends to a depth of 30 inches and is separated into three parts. The upper 6 inches is about 60 percent weathered limestone fragments 1 to 3 inches

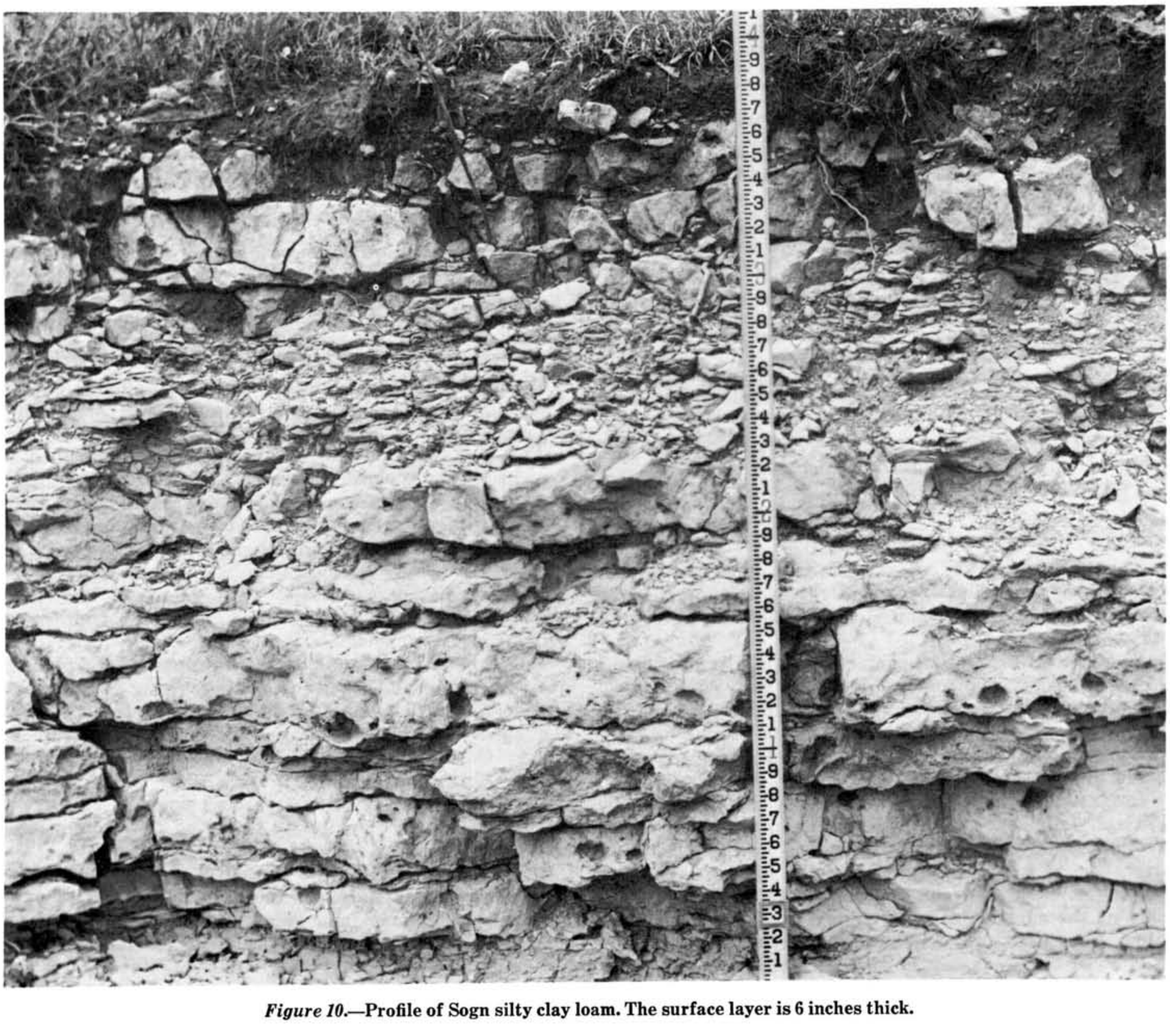

Figure 10.—Profile of Sogn silty clay loam. The surface layer is 6 inches thick.

thick and 10 to 15 inches long, and 40 percent very dark grayish-brown silty clay loam. The middle 6 inches is level-bedded limestone that has cracks filled with dark grayish-brown heavy silty clay loam. The lower 10 inches is somewhat weathered limestone that has cracks filled with light olive-brown clayey shale.

Sogn soils have moderate permeability and very low available water capacity. They are medium in natural fertility.

Sogn soils are used for range and wildlife. Such deciduous trees as Osage-orange and locust and woody shrubs have invaded some areas.

The Sogn soils in Richardson County are mapped only with Kipson soils.

Typical profile of Sogn silty clay loam, in an area of Kipson-Sogn complex, 3 to 30 percent slopes, located in the northwest corner of the SW¼NE¼ sec. 27, T. 1 N., R. 13 E.:

A—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) when dry; moderate, coarse, granular structure; friable when moist, hard when dry; weakly calcareous; medium to large limestone fragments cover 15 percent of the surface; mildly alkaline; gradual, smooth boundary.

R1—8 to 14 inches, about 60 percent loosely fixed weathered limestone and 40 percent very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) when dry; calcareous; clear, smooth boundary.

R2—14 to 20 inches, level-bedded limestone with separations and joints 2 to 4 inches in depth and 15 to 20 inches in length and width, cracks filled with dark grayish-brown (2.5Y 4/2) heavy silty clay loam; gradual, smooth boundary.

R3—20 to 30 inches, weathered limestone with separations and joints 4 to 6 inches in depth and 15 to 30 inches in length and width; cracks filled with light olive-brown (2.5Y 5/4) clayey shale.

The A horizon ranges from 5 to 14 inches in thickness and has few to many limestone fragments. In places beds of platy, clayey shale alternate with beds of limestone below a depth of 30 inches.

Sogn soils are in the same general areas as Kipson soils. They are shallow over limestone, whereas Kipson soils are shallow over shale.

Wabash Series

The Wabash series consists of deep, poorly drained, nearly level soils that formed in clayey alluvium. These soils are on the bottom land along the Nemaha River and its tributaries.

In a typical profile, the surface layer is silty clay about 30 inches thick. The upper 7 inches is very dark brown, the middle 8 inches is black, and the lower 15 inches is very dark gray. The 20-inch transitional layer is very dark gray, very firm silty clay. The underlying material, below a depth of 50 inches, is dark-gray silty clay.

Because they have slow permeability and slow runoff, Wabash soils are poorly drained. They are moderate in available water capacity. They are medium acid or slightly acid in the upper part of the surface layer and are slightly acid, neutral, or mildly alkaline in the lower part of the surface layer. They are high in natural fertility. Poor tilth and wetness are concerns.

Most of the acreage is cultivated. Some areas are used for grass and are also suited to windbreaks.

Typical profile of Wabash silty clay, 0.5 mile south and 0.12 mile east of the northwest corner of sec. 2, T. 1 N., R. 15 E.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silty clay, very dark gray (10YR 3/1) when dry; weak, coarse, blocky structure parting to weak, fine, granular; very firm when moist, very hard when dry; slightly acid; abrupt, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) silty clay, very dark gray (2.5Y 3/0) when dry; moderate, coarse, blocky structure parting to moderate, medium and fine, subangular blocky; very firm when moist, extremely hard when dry; few, fine, dark accumulations; slightly acid; gradual, smooth boundary.

A3—15 to 30 inches, very dark gray (10YR 3/1) silty clay, very dark gray (2.5Y 3/0) when dry; moderate, coarse, blocky structure parting to moderate, medium and fine, subangular blocky; very firm when moist, extremely hard when dry; few, dark accumulations (iron or manganese oxides); neutral; gradual, smooth boundary.

ACg—30 to 50 inches, very dark gray (10YR 3/1) silty clay, dark gray (2.5Y 4/0) when dry; moderate, coarse, blocky structure parting to moderate, medium and fine, angular blocky; very firm when moist, very hard when dry; common, fine, faint, dark-brown mottles; few, fine, dark accumulations (iron or manganese oxides); mildly alkaline; gradual, smooth boundary.

Cg—50 to 60 inches, dark-gray (10YR 4/1) silty clay, gray (2.5Y 5/0) when dry; moderate, medium, subangular blocky structure; very firm when moist, very hard when dry; few, dark-brown concretions; mildly alkaline.

The Ap and A12 horizons range from silty clay to light silty clay loam.

Wabash soils are in the same general areas as the Kennebec, Hobbs, and Zook soils. They have more clay throughout the profile and poorer drainage than Kennebec and Hobbs soils. They have more clay in the upper part of the profile than Zook soils. They are similar in texture but are darker and more acid throughout the profile than Albaton soils, which occur on the bottom land along the Missouri River.

Wabash silty clay loam (0 to 1 percent slopes) (Ws).—This soil occupies broad tracts mainly on the bottom land along the Nemaha River and Muddy Creek.

This soil has a profile similar to the one described as typical for the Wabash series, but the upper 6 to 16 inches of the surface layer is silty clay loam. Included in mapping were small areas of Zook silty clay loam and Slickspots and areas near upland slopes that are seeped.

Runoff is slow, permeability is slow, and available water capacity is moderate. This soil dries slowly in spring and during rainy periods. The main concern of management is drainage.

This soil is best suited to such crops as late planted grain sorghum and soybeans, close-growing small grain, and deep-rooted legumes. It is least suited to corn. It is also suited to grasses and trees. Capability unit IIw-2; Clayey Overflow range site; Moderately Wet windbreak group.

Wabash silty clay (0 to 1 percent slopes) (Wa).—This soil commonly occupies broad tracts on the bottom land along the Nemaha River and Muddy Creek.

This soil has the profile described as typical for the Wabash series. Included in mapping were areas of Wabash silty clay loam and small areas of Slickspots. In places side drainageways have cut deep channels.

Because of the clayey texture, slow permeability, and slow runoff, this soil has poor tilth and limitations associated with wetness. It dries slowly in spring and stays wet during periods of above normal rainfall. When dry, this soil is very hard. Preparing a good seedbed is difficult.

This soil is best suited to such crops as late planted grain sorghum and soybeans, fall-sown crops, and deep-rooted legumes. It is well suited to grasses. It is also suited to windbreak plantings. Capability unit IIIw–1; Clayey Overflow range site; Moderately Wet windbreak group.

Wet Alluvial Land

Wet alluvial land (0 to 1 percent slopes) (Wx) is in small, shallow depressions or basins in the bottom land and on foot slopes where underground water flows to the surface as springs. Its texture varies, but to a depth of 40 inches or more is mainly silt loam, silty clay loam, and silty clay. The upper 30 inches is black, dark gray, or very dark grayish brown, contains many partly decomposed stems and leaves, and has brown stains along root channels. Below this the soil material is stratified and is mottled with black, very dark gray, or dark grayish brown. Wet alluvial land is very poorly drained in most areas. It is difficult to drain artificially and is too wet for cultivated crops. The water table fluctuates from a depth of 3 feet to the surface.

Wet alluvial land is suited to grasses and wildlife habitat. The vegetation is mostly grasses and sedges. Cattails, rushes, and willows grow in some places. Capability unit Vw–1; Wet Land range site; Very Wet windbreak group.

Wymore Series

The Wymore series consists of deep, moderately well drained, nearly level to strongly sloping soils that formed in grayish-brown loess. These soils are on the uplands.

In a typical profile, the surface layer is very dark brown silty clay loam about 14 inches thick (fig. 11). The subsoil is about 31 inches thick. The upper 4 inches is very dark grayish-brown, firm silty clay; the next 13 inches is dark grayish-brown, very firm silty clay; the next 9 inches is olive-brown, very firm silty clay; and the lower 5 inches is dark grayish-brown, firm heavy silty clay loam. The underlying material is grayish-brown silty clay loam.

Wymore soils have slow permeability and high available water capacity. They are slightly acid or medium acid in the surface layer and upper part of the subsoil and slightly acid or neutral in the middle and lower parts of the subsoil. They are high in natural fertility.

Typical profile of Wymore silty clay loam, 1 to 3 percent slopes, 0.25 mile north and 95 feet west of the southeast corner of sec. 9, T. 3 N., R. 13 E.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) when dry; weak, coarse, blocky structure parting to weak, fine, granular; friable when moist, hard when dry; medium acid; abrupt, smooth boundary.

A12—7 to 14 inches, very dark brown (10YR 2/2) silty clay loam, very dark gray (10YR 3/1) when dry; weak, medium and fine, subangular blocky structure parting to weak, fine, granular; friable when moist, hard when dry; medium acid; gradual, smooth boundary.

B1t—14 to 18 inches, very dark grayish-brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) when dry; weak, medium and fine, subangular blocky structure; firm when moist, very hard when dry; shiny surfaces on peds; medium acid; gradual, smooth boundary.

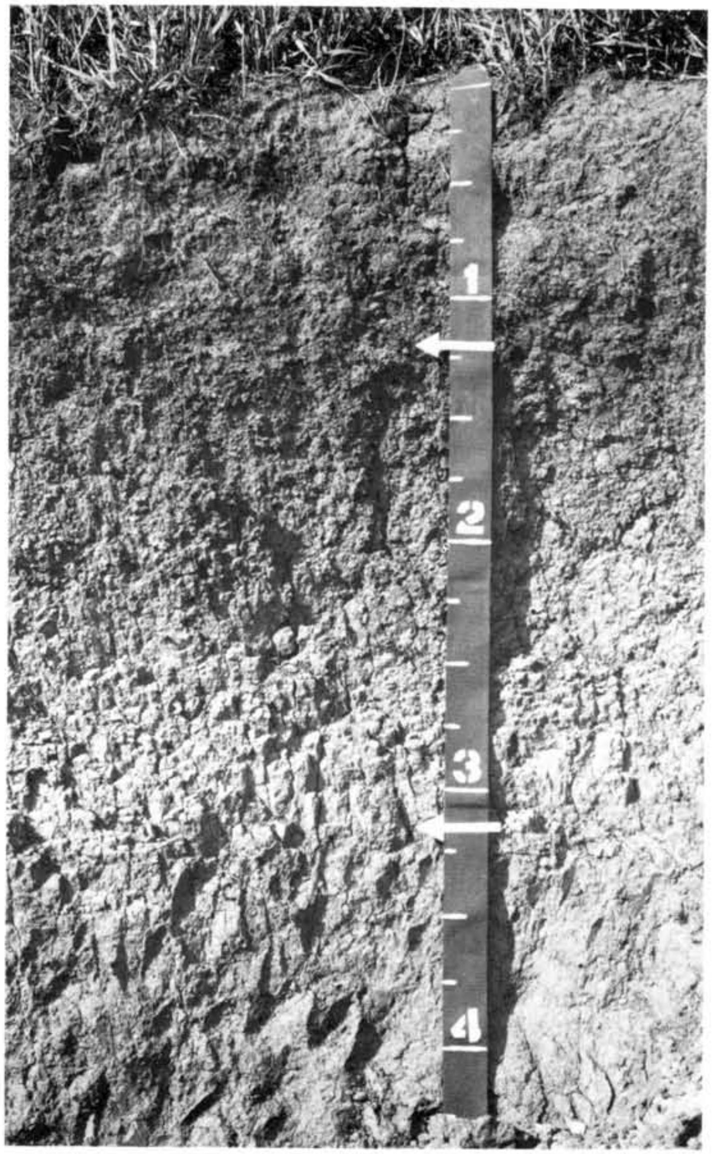

Figure 11.—**Profile of Wymore silty clay loam showing 14-inch surface layer. Grayish subsoil extends to a depth of about 14 inches. Below a depth of 40 inches is a buried soil in glacial deposits.**

B21t—18 to 31 inches, dark grayish-brown (2.5Y 4/2) silty clay, grayish brown (2.5Y 5/2) when dry; weak, coarse, prismatic structure parting to moderate, medium and fine, blocky structure; very firm when moist, extremely hard when dry; shiny surfaces on peds; few, fine, faint, dark-brown mottles; slightly acid; gradual, smooth boundary.

B22t—31 to 40 inches, olive-brown (2.5Y 4/3) silty clay, grayish brown (2.5Y 5/2) when dry; weak, coarse, prismatic structure parting to moderate, medium, blocky; very firm when moist, very hard when dry; shiny surfaces on peds; few, fine, faint, strong-brown mottles; few, coarse, dark accumulations (iron or manganese oxides); slightly acid; gradual, smooth boundary.

B3—40 to 45 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam, light brownish gray (10YR 6/2) when dry; weak, coarse, prismatic structure parting to moderate, medium, blocky; firm when moist, very hard when dry; few, fine, faint, dark yellowish-brown mottles; many fine, dark accumulations (iron or manganese oxides); few lime concretions ;neutral; gradual, smooth boundary.

C—45 to 60 inches, grayish-brown (10YR 5/2) silty clay loam, light gray (10YR 7/2) when dry; weak, medium and coarse, blocky structure; friable when moist, hard when dry; common, medium, distinct, dark yellowish-brown, yellowish-brown, and gray mottles; few, fine, faint, dark accumulations (iron or manganese oxides); neutral.

The Ap horizon ranges from 5 to 9 inches in thickness. In some eroded areas, the A1 horizon is absent, and the Ap is underlain by the B1t or B2t horizon. In areas of native sod, there is no Ap horizon and the A horizon ranges from 10 to 18 inches in thickness. Reaction in the Ap, A12, and B1t horizons ranges from slightly acid to medium acid. In places buried horizons of older soils are in the C horizon.

The Wymore soils in mapping unit Wt have a thicker A horizon and a darker upper B horizon than is defined for the series. In mapping unit WtD3 they have a thinner, lighter colored A horizon than is defined for the series. These differences, however, do not alter the usefulness or behavior of the soils.

Wymore soils are in the same general areas as Sharpsburg soils, but to the west of those soils. Their B horizon is more clayey and grayer than that of Sharpsburg soils. They have less grit throughout the profile than Pawnee soils, which are downslope and formed in glacial deposits.

Wymore silty clay loam, 0 to 1 percent slopes (Wt).—This soil occupies broad upland divides and high benches. It has a profile similar to the one described as typical for the Wymore series, but the surface layer is slightly thicker, and the upper subsoil is slightly darker colored.

Tillage is easy to perform, and fertility is easy to maintain. Permeability is slow. The droughty nature of this soil, particularly during hot, dry weather, is a concern in management.

Nearly all of the acreage is cultivated. This soil is suited to all crops commonly grown in the county, but is best suited to grain sorghum and wheat. It is also suited to grasses and windbreak plantings. Capability unit IIs–2; Clayey range site; Silty to Clayey windbreak group.

Wymore silty clay loam, 1 to 3 percent slopes (WtA).—This soil occupies narrow tracts on ridgetops and a few broad tracts on high benches.

This soil has the profile described as typical for the Wymore series. Included in mapping were some areas of Sharpsburg soils.

Available water capacity is high, permeability is slow, and runoff is medium. Controlling erosion is a slight concern in management.

Nearly all of the acreage is cultivated. This soil is suited to all crops commonly grown in the county. It is best suited to grain sorghum and wheat, and least suited to corn. It is also suited to grasses and windbreak plantings. Capability unit IIe–2; Clayey range site; Silty to Clayey windbreak group.

Wymore silty clay loam, 3 to 9 percent slopes (WtC).—This soil occupies intermittent tracts on ridges and valley sides. It has a profile similar to the one described as typical of the series, but the surface layer is slightly thinner. Included in mapping were areas of Sharpsburg soils.

Available water capacity is high, permeability is slow, and runoff is rapid. Where this soil is cultivated, the erosion hazard is severe.

About 25 percent of the acreage is cultivated, and about 75 percent is in grass. This soil is suited to all crops commonly grown in the county. It is least suited to corn and soybeans. It is also suited to grasses and windbreaks. Capability unit IIIe–2; Clayey range site; Silty to Clayey windbreak group.

Wymore silty clay loam, 3 to 9 percent slopes, eroded (WtC2).—This soil has smooth slopes. It occupies broad tracts on ridgetops and valley sides.

This soil has a profile similar to the one described as typical for the Wymore series, but erosion has removed about half of the original surface layer, and the present surface layer is about 7 inches thick. Included in mapping were some areas of Sharpsburg soils.

Permeability is slow, and runoff is rapid. The erosion hazard is severe. The main concern of management is erosion. Maintaining good tilth is a minor concern.

About 75 percent of the acreage is cultivated, and about 25 percent is in grass. This soil is suited to grain sorghum, wheat, corn, soybeans, clover, alfalfa, grasses, and windbreak plantings. It is least suited to corn and alfalfa. Capability unit IIIe–2; Clayey range site; Silty to Clayey windbreak group.

Wymore silty clay loam, 9 to 12 percent slopes, eroded (WtD2).—This soil occupies a few small tracts on valley sides near drainageways. It has a profile similar to the one described as typical for the Wymore series, but the surface layer is a few inches thinner.

Permeability is slow. Where this soil is cultivated, it is subject to rapid runoff. It is difficult to maintain grassed waterways or to operate farm machinery on the slopes. The erosion hazard is severe. Controlling erosion is a necessary part of good management.

This soil is suited to small grain and legumes and to some extent to corn and soybeans. It is well suited to hay, pasture, and range. More than half the acreage is in grass. Capability unit IVe–2; Clayey range site; Silty to Clayey windbreak group.

Wymore silty clay loam, 3 to 12 percent slopes, severely eroded (WtD3).—This soil occupies a few small to medium size tracts mainly on valley sides near drainageways. It has a soil profile similar to the one described as typical for the Wymore series, but the surface layer is lighter colored and is less than 7 inches thick. Part of the silty clay subsoil has been mixed into the surface layer.

Tilth is poor, the organic-matter content is moderately low, and permeability is slow. Runoff is rapid and the erosion hazard is severe. The main concerns of management are controlling erosion, improving tilth, and increasing fertility.

This soil is suited to grain sorghum, wheat, and legumes. It is well suited to hay, pasture, range, and wildlife.

In places, areas of this soil are within larger tracts of soil that is better suited to cultivation. In these places additions of manure or fertilizers are beneficial. Capability unit IVe–4; Dense Clay range site; Silty to Clayey windbreak group.

Zook Series

The Zook series consists of deep, somewhat poorly drained, nearly level soils that formed in silty and clayey alluvium. These soils are on the bottom land along the Nemaha River and its tributaries.

In a typical profile, the surface layer is black silty clay loam about 25 inches thick. Below this is a very dark gray, firm light silty clay transitional layer about 13 inches thick. The underlying material is dark-gray, firm light silty clay.

Zook soils have slow permeability and high available water capacity. They are commonly slightly acid throughout the profile but neutral in the underlying material. Zook soils are high in natural fertility. Wetness is a concern in management.

Most of the acreage is cultivated. These soils are also suited to grass.

Typical profile of Zook silty clay loam, 270 feet west of the center of sec. 20, T. 1 N., R. 16 E.:

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; weak, medium, blocky structure; friable when moist, hard when dry; medium acid; compacted plow sole at a depth of 6 inches; abrupt, smooth boundary.

A12—6 to 25 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) when dry; compound, weak, medium and coarse, subangular blocky structure parting to weak, medium, granular; friable when moist, hard when dry; slightly acid; gradual, smooth boundary.

AC—25 to 38 inches, very dark gray (10YR 3/1) light silty clay, dark gray (10YR 4/1) when dry; compound, weak, coarse, blocky structure parting to moderate, medium, subangular blocky; firm when moist, very hard when dry; many, fine, dark accumulations (iron or manganese oxides); slightly acid; gradual, smooth boundary.

Cg—38 to 60 inches, dark-gray (10YR 4/1) light silty clay, gray (10YR 5/1) when dry; moderate coarse and medium, blocky structure; firm when moist, very hard when dry; few, fine, dark accumulations (iron or manganese); common, medium, distinct, strong-brown mottles; neutral.

The depth to silty clay ranges from 20 to 40 inches. In places the Ap horizon is slightly acid, very dark grayish-brown light silty clay loam. In places the Cg horizon is mildly alkaline.

Zook soils are in the same general areas as Wabash and Kennebec soils. They have poor drainage as do Wabash soils, but they have less clay in the upper part of the profile. They have more clay throughout the profile and are more poorly drained than Kennebec soils.

Zook silty clay loam (0 to 1 percent slopes) (Zo).—This soil occupies broad tracts on the bottom land along the Nemaha River and Muddy Creek.

Included in mapping were tracts of Wabash silty clay loam and Kennebec silt loam, and areas where the water table is within a depth of 5 feet and seepage occurs.

This soil has high available water capacity, slow runoff, and slow permeability. It dries slowly in spring and during rainy periods. Wetness is a slight concern in management.

Most of the acreage is cultivated. This soil is suited to all crops commonly grown in the county. It is well suited to such crops as late-planted grain sorghum and soybeans, close-growing small grain, and deep-rooted legumes. It is also suited to grasses and windbreak plantings. Capability unit IIw-4; Clayey Overflow range site; Moderately Wet windbreak group.

Use and Management of the Soils

This section describes management of soils used for crops, tame grass pasture, range, windbreaks, wildlife, and recreation. It explains the system of capability classification used by the Soil Conservation Service and shows estimated yields of the principal crops grown in the county under customary and improved management.

This part of the survey also contains information on range sites and farm windbreaks and general suggestions for improvement of wildlife habitat. It also reports data from engineering tests and interpretations of soil properties that affect construction of highways and other engineering structures.

Management of the Soils for Crops

Each year from 50 to 70 percent of the acreage in Richardson County is cultivated. Corn is the principal crop. Grain sorghum, wheat, soybeans, and alfalfa are other important crops. Each year some cropland is used for temporary pasture or for soil improvement grasses and legumes.

The main considerations in managing cultivated soils in this county are conserving moisture; controlling runoff and erosion; maintaining fertility, tilth, and organic-matter content; and providing drainage. Suitable management provides an appropriate cropping system, cultivation on the contour, sodded waterways, crop residue management, fertilization, and suitable plant population in relation to soil moisture and fertility (fig. 12). Practices suitable for most of the soils used for crops in the county are described in the paragraphs that follow.

Cropping systems.—A cropping system consists of a sequence of crops grown on a given area over a period of time. The objectives of a well-planned cropping system are to maintain high fertility, soil structure, and good tilth; to help protect the soils from erosion; to conserve moisture by controlling weeds; and to control insect pests and plant diseases. A good cropping system includes crops best suited to the soil and to the nature of the farming enterprise.

Minimum tillage.—Minimum tillage is the practice of using the minimum amount of tillage needed to produce a crop. Plow and disk harrow are seldom used but are replaced by a tool that stirs the soil and plants the seeds without completely turning under the litter from the preceding crop. Instead of tilling to control weeds, fields are sprayed before the weeds emerge. Because excessive tillage compacts the soil and breaks down soil structure, the soil tends to puddle when wet and to crust when dry. These conditions impede the movement of water into the soil. Soils have to be worked at optimum moisture content when the weather is favorable in order for this practice to be successful.

Residue management.—Residue management emphasizes the use of crop residue left on the surface after

Figure 12.—Crops and pasture on well-managed Wymore soil. Contouring, grass waterways, and contour fencing are essential in management.

harvest. The objectives are to conserve moisture by reducing evaporation, limiting runoff, and increasing infiltration; to protect the soil from erosion; and to maintain fertility. Crop residue protects the surface of the soil from the impact of raindrops, prevents the soil from forming a surface-sealing crust, and increases the moisture intake rate. This is particularly beneficial for Albaton, Pawnee, Wabash, and Wymore soils. Residue left over winter catches drifting snow and helps conserve moisture. Residue also adds organic matter that improves soil tilth and helps to maintain the supply of plant nutrients. Where stubble-mulch tillage is used, crop residue remains on or near the surface and protects the soils throughout the year. Surface residue keeps erosion to a minimum on the gently sloping and sloping Marshall, Monona, and Morrill soils.

Terracing and contouring.—Terracing and contour farming are mechanical conservation practices. Terraces are ridges that are constructed across slopes to intercept runoff. Contour farming is tilling and planting across the slope on the contour, or parallel to terraces. Furrows and wheel tracks are then nearly level. Each row planted on the contour is a miniature terrace that holds back water. Terracing and contouring help protect the soils from erosion, conserve moisture, and maintain fertility. These practices can be useful on the sloping Marshall, Morrill, and Sharpsburg soils.

Grass waterways.—Grass waterways are generally small upland drainageways that are protected by a permanent grass cover. They help control erosion, provide safe outlets for surplus water from terraced and cultivated fields, and provide safe crossings for farm machinery. Most drainageways have to be shaped, leveled, and diked before they are seeded to a mixture of suitable grasses. Waterways commonly are useful in areas of Sharpsburg, Monona, Wymore, and Marshall soils.

Fertilizer.—Commercial fertilizers maintain a balanced supply of plant nutrients. Most cultivated soils in Richardson County are high in natural fertility, but additional nutrients are sometimes needed, particularly if crops grow rapidly. Nitrogen, phosphorus, and calcium are likely to be deficient. Cropping history and soil tests indicate the kinds and amounts of fertilizer or lime needed for particular soils and specific crops. Fertilization is most effective if used with other conservation practices, such as residue management and contouring. The amount of fertilizer can be adjusted to the available soil moisture and plant population.

Drainage systems.—Drainage systems are used to prevent accumulation of water or to remove excess water in the soil or on the surface. The objectives are to provide a favorable medium for plants to grow and to provide access for tillage. Surface drainage can be improved by such simple tillage methods as row direction of crops or surface bedding. Another good method is land grading and leveling. Tile drains are used for underground water table and seepage areas. Diversion embankments intercept runoff water. Drainage is a practice that has special application in areas of Albaton and Wabash soils.

Management of the Soils for Tame Grass Pasture [3]

Tame grass pastures in Richardson County consist mainly of cool-season grasses. These grasses start to grow early in spring and reach peak growth in May or June. They tend to be dormant during the warm summer months of July and August, but start to grow again in cool, fall months. For this reason, it is desirable to have warm-season pasture or range consisting of native grasses or temporary pastures of sudangrass that attain peak growth during July and August—the time when tame grasses are semidormant. This combination provides green plants during the entire growing season.

Tame pastures are best suited to soils that can be cultivated or used in rotation with cultivated crops. Tame grasses yield more forage than native grasses, but are more costly to maintain. Best results are obtained by plowing out stands when they begin to deteriorate. It is important that soils can be plowed and reseeded without danger of runoff and erosion.

Introduced grasses are used for tame grass pastures. Bromegrass is the species most commonly grown in this county, but orchardgrass, tall fescue, and reed canarygrass are also grown. A legume, such as alfalfa or birdsfoot trefoil, in the planting system is desirable.

The management of tame pasture is geared to grazing late in spring and in fall, after the grasses reach a height of 5 or 6 inches. Until the plants reach this height, they grow on food reserves stored in their roots and rhizomes. Grazing too early in spring or too late in fall weakens the plants. Sufficient leaf growth is necessary for healthy plants and also for storing food reserves for the next season.

Weeds can be controlled by the use of chemicals. Mowing clips off the taller grasses and may do as much damage to the grasses as the weeds do.

Tame grasses respond to fertilizers, but soil tests and estimates of the amount of available soil moisture are used as guides to determine the amounts and kinds of fertilizer to apply. Grasses are likely to need nitrogen. If a legume is included, phosphate fertilizer generally is needed.

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[3] By Ervin O. Peterson, conservation agronomist, and Howard E. Sautter, soil scientist, Soil Conservation Service.

Capability Grouping

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

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

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

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

Class I soils have few limitations that restrict their use.

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

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

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.

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

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in Richardson County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, 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 (*8*). Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or VIs-4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Richardson County are described and suggestions for the use and management of the soils are given. The names of the soil series represented are mentioned in the description of each unit, but this does not mean that all the soils in a given series are in the unit. The capability unit designation for each soil in the county can be found in the "Guide to Mapping Units."

CAPABILITY UNIT I-1

This unit consists of deep, well drained and moderately well drained, nearly level and very gently sloping soils of the Kennebec, Marshall, Nodaway, and Sharpsburg series. These soils are on bottom land and uplands. They have a surface layer of silt loam or silty clay loam and a subsoil or underlying material of silt loam or silty clay loam.

These soils are easily worked. Permeability is moderate or moderately slow, and the available water capacity is high. The soil texture, permeability, and porosity (the soil-moisture-air relationship) favor plant growth. The soil takes in water readily and releases it readily to plants. Fertility is easily maintained.

These soils are among the best in the county for cultivated crops. They are suited to all crops commonly grown in the county. Corn is the main crop. Grain sorghum, soybeans, and wheat are grown also.

By using good management practices, such as a cropping system, residue management, and fertilization, these soils can be cultivated intensively without risk of damage. Proper plant population according to the amount of soil moisture, timely tillage, and minimum tillage are also good practices.

CAPABILITY UNIT IIe-1

This unit consists of deep, well drained and moderately well drained, very gently sloping and gently sloping soils of the Judson, Marshall, Monona, and Sharpsburg series. These soils are on uplands and foot slopes. They have a surface layer and subsoil of silt loam or silty clay loam.

These soils are easy to work. Permeability is moderate or moderately slow, and the available water capacity is high. The soil texture, permeability, and porosity (the soil-moisture-air relationship) favor plant growth. The soil takes in water readily and releases it readily to plants.

Because of the gentle slopes, some runoff occurs, subjecting these soils to damage by erosion unless they are well managed.

These soils are suited to all the crops commonly grown in the county. Corn and grain sorghum are the major crops. Wheat, soybeans, clover, and alfalfa are also grown.

A suitable cropping system, crop residue management, fertilization, and contour farming or a similar practice is needed to help control erosion and conserve moisture. In places terracing is suitable. A diversion terrace or embankment that intercepts runoff from adjacent slopes can be used to protect Judson soils.

CAPABILITY UNIT IIe-2

Wymore silty clay loam, 1 to 3 percent slopes, is the only soil in this unit. This is a deep, moderately well drained, very gently sloping soil on uplands and high benches. It has a silty clay subsoil.

Available water capacity is high, and permeability is slow. Fertility is easily maintained. During thunderstorms runoff is medium, and unless well managed, this soil is subject to erosion.

Grain sorghum and wheat are the main crops, but corn, soybeans, clover, and alfalfa are also grown. Grain sorghum tolerates hot, dry periods. Wheat is a cool-season crop that utilizes moisture from rains early in spring and moisture stored during the previous season.

A good cropping system, crop residue management, fertilization, and contour farming or a similar practice is needed to help control erosion and conserve moisture. In places terracing is suitable.

CAPABILITY UNIT IIs-2

Wymore silty clay loam, 0 to 1 percent slopes, is the only soil in this unit. This is a deep, moderately well drained, nearly level soil on uplands and high benches. The subsoil is silty clay.

This soil is easy to work, and fertility is easy to maintain. Available water capacity is high, but permeability is slow; consequently the soil releases moisture and nutrients slowly to plants. The soil is somewhat droughty, particularly in hot dry weather. The main concern in management is choosing crops that are best adapted to the climate and to soil fertility.

Grain sorghum, the main crop, tolerates hot, dry periods. Wheat is a cool-season crop that grows well on this soil. Corn, soybeans, and clover are also grown during years of favorable moisture.

By using good management practices, this soil can be cultivated intensively without risk of damage. A good cropping system, residue management, fertilization, minimum tillage, and proper plant population, according to the amount of soil moisture, are needed.

CAPABILITY UNIT IIw-2

Wabash silty clay loam is the only soil in this unit. This is a deep, poorly drained, nearly level soil on bottom land. The upper part of the surface layer is friable silty clay loam that ranges from 6 to 16 inches in thickness. Below this is very firm silty clay.

Runoff is slow, permeability is slow, and available water capacity is moderate. This soil drains and dries slowly during rainy periods, and wetness delays tillage.

This soil is best suited to grain sorghum, soybeans, wheat, and alfalfa. Grain sorghum or soybeans can be planted later than corn. Some varieties of wheat are suitable for planting during mild fall weather. Alfalfa utilizes the soil moisture, and the tap roots help to open the clayey part of the soil. Corn is suitable if the weather is favorable.

Soil drainage can be improved by correct row direction, surface bedding, or land grading and leveling. In places of seepage, tile drains are suitable. A good cropping system, residue management, timely tillage, and fertilization are needed to maintain high fertility, soil structure, and good tilth.

CAPABILITY UNIT IIw-3

This unit consists of deep, moderately well drained, nearly level Haynie and Hobbs soils and small areas of poorly drained Albaton soils and excessively drained Sarpy soils. All are on bottom land.

In most areas Haynie and Hobbs soils have a silt loam surface layer and a silt loam or very fine sandy loam subsoil. They are easy to till and have moderate permeability and high available water capacity. The poorly drained, clayey Albaton soils have poor tilth, slow permeability, and moderate available water capacity. The excessively drained, sandy Sarpy soils have rapid permeability and low available water capacity.

These soils are subject to occasional flooding. Otherwise, they are among the best soils in the county for cultivated crops. They are suited to all the crops commonly grown in the county. Corn is the chief crop, but grain sorghum and soybeans, and to a lesser extent wheat and alfalfa, are also grown. Wheat is least suitable because of lodging and the possibility of flooding and wetness at harvest time. Corn grown on the Sarpy soil is generally affected by droughtiness in dry periods. In some years occasional flooding is beneficial to crops because it adds to the moisture supply.

By using good management practices, such as a cropping system, residue management, minimum tillage, and fertilization, these soils can be farmed intensively without risk of damage. Flooding can best be controlled by applying conservation measures in the upstream watershed and by building flood control structures. In places dikes and diversions have been built to protect the soils from overflow.

CAPABILITY UNIT IIw-4

Zook silty clay loam is the only soil in this unit. This is a deep, somewhat poorly drained, nearly level soil on bottom land. The surface layer is friable silty clay loam about 25 inches thick. Below this is firm silty clay.

Fertility is easy to maintain, and available water capacity is high. Runoff is slow, and permeability is slow.

The main limitation is wetness. The soil dries slowly in spring and during rainy periods, and tillage is often delayed. In places seepage is a limitation.

This soil is suited to many of the crops grown in the county. Grain sorghum and soybeans can be planted later than corn, and wheat or legumes can be planted during mild fall weather. Corn is suitable if the soil is drained and the weather is favorable.

Soil drainage can be improved by correct row direction, surface bedding, or land grading and leveling. In places of seepage, tile drains are suitable. A good cropping system, residue management, fertilization, and timely tillage are also needed to maintain high fertility, soil structure, and good tilth.

CAPABILITY UNIT IIIe-1

This unit consists of deep, well drained and moderately well drained, sloping and strongly sloping soils of the Geary, Marshall, Monona, Morrill, and Sharpsburg series. These soils are slightly or moderately eroded. They have a surface layer and subsoil of silty clay loam, silt loam, or clay loam.

These soils are easy to work. Permeability is moderate or moderately slow, and available water capacity is high. The soil texture, permeability, and porosity (the soil-moisture-air relationship) favor plant growth. The soil takes in water readily and releases it readily to plants.

Because of slope, runoff is rapid during thunderstorms, and the soils can be severely damaged by erosion unless they are well managed.

These soils are suited to all crops commonly grown in the county. Corn, soybeans, clover, and alfalfa are the main crops, but grain sorghum and wheat are also grown.

Mechanical practices, such as terracing, constructing grassed waterways, and farming on the contour, help to control runoff and erosion. Establishing a good cropping system, managing residue, and fertilizing are essential to help control runoff, conserve moisture, and maintain fertility, soil structure, and good tilth. Under intensive management, more years of row crops can be included in the cropping system.

CAPABILITY UNIT IIIe-2

This unit consists of deep and moderately deep, well drained and moderately well drained soils of the Benfield, Pawnee, Mayberry, and Wymore series. These gently sloping or sloping, moderately eroded soils are on uplands. The surface layer is silty clay loam or clay loam, and the subsoil is silty clay or clay.

Available water capacity is high in Wymore soils and moderate in the rest. Permeability is slow. Runoff is rapid during thunderstorms, and unless well managed, the soils are subject to severe erosion.

Grain sorghum and wheat are the chief crops, but corn, alfalfa, clover, and soybeans are also grown. Because these soils release moisture slowly to plants, sorghum is more suitable than corn because it tolerates hot dry periods. Wheat is a cool-season crop that utilizes moisture from spring rains and soil moisture stored during the previous season. Because of the erosion hazard and moderate available moisture, the most suitable cropping system consists mainly of wheat and clover and other close-growing crops.

Under intensive management, more years of row crops can be included in the cropping system. Intensive management includes such practices as terracing, constructing grassed waterways, and farming on the contour, all of which help to control runoff and erosion. Crop residue management and fertilization are needed.

CAPABILITY UNIT IIIe-8

This unit consists of deep, well drained and moderately well drained, sloping and strongly soils of the Marshall, Monona, and Sharpsburg series. These are eroded and severely eroded soils on uplands. They have a thin surface layer of silty clay lòam or silt loam that is moderately low in organic-matter content. Their subsoil is silty clay loam or silt loam.

Permeability is moderate or moderately slow, available water capacity is high, and runoff is rapid. The soil texture, permeability, and porosity (the soil-moisture-air relationship) favor plant growth. The soil takes in water readily and releases it readily to plants. Response to management is excellent.

Unless properly managed, these soils are subject to further erosion. The main management needs are controlling runoff and erosion and improving and maintaining fertility and the organic-matter content.

These soils are suited to all crops commonly grown in the county. Corn, soybeans, clover, and alfalfa are the chief crops. Grain sorghum and wheat are also grown.

Such mechanical practices as terracing, constructing grassed waterways, and contour farming help in controlling runoff and erosion. A good cropping system, crop residue management, and fertilization help to control runoff, conserve moisture, and maintain fertility, soil structure, and good tilth. Green manure crops and barnyard manure improve the organic-matter content and the fertility of the soils. Under intensive management, more years of row crops can be included in the cropping sequence.

CAPABILITY UNIT IIIw-1

This unit consists of deep, poorly drained, nearly level soils of the Albaton, Onawa, and Wabash series. These soils are on bottom land. They have a very firm silty clay texture.

Permeability is slow, and runoff is slow. Available water capacity is high in the Onawa soil and moderate in the rest.

These soils are difficult to work. They drain and dry slowly, and wetness delays tillage, especially during rainy periods. Good tilth is hard to maintain, because the soils are sticky when wet and very hard dry. Tillage must be done at the proper moisture content.

These soils are best suited to grain sorghum, soybeans, wheat, and alfalfa. Grain sorghum and soybeans can be planted later than corn. The soil can be worked in summer, and wheat can be planted during mild fall weather. Legumes, especially alfalfa, have deep tap roots that tend to open the clayey soil. Alfalfa also makes good use of moisture deep in the soil. Forage sorghum for livestock feed is also grown.

Correct row direction, surface bedding, and land grading and leveling improve drainage. In places of seepage from underground water, tile drains are used. Crop residue management, timely tillage, and fertilization are needed to maintain high fertility, soil structure, and good tilth.

CAPABILITY UNIT IVe-1

This unit consists of deep, well-drained, moderately steep soils of the Monona and Morrill series. These slightly eroded and moderately eroded soils are on uplands. They have a surface layer and subsoil of silt loam or clay loam.

Permeability is moderate and moderately slow, and available water capacity is high. The soil texture, permeability, and porosity (the soil-moisture-air relationship) favor plant growth. The soil takes in water readily and releases it readily to plants.

These soils have good tilth, but the steep slopes and the erosion hazard limit their use for cultivated crops and also limit the use of farm machinery.

These soils are suited to wheat, clover, and alfalfa. Clean-cultivated row crops, such as corn, soybeans, and grain sorghum, are also grown. Unless conservation practices for cultivated crops are used, these soils are best suited to permanent grass. At present, many areas are in grass.

Terracing, constructing grassed waterways, and farming on the contour are the principal practices used to control runoff and erosion. Residue management, minimum tillage, and fertilization are needed to help control runoff, conserve moisture, and maintain fertility and good tilth.

CAPABILITY UNIT IVe-2

This unit consists of deep, moderately well drained, strongly sloping soils of the Pawnee, Mayberry, and Wymore series. These slightly and moderately eroded soils are on uplands. They have a surface layer of clay loam or silty clay loam and a subsoil of clay or silty clay.

Available water capacity is high in the Wymore soil and moderate in the rest. Permeability is slow. Where these soils are cultivated, they are subject to runoff and severe erosion during rainstorms. The steep slopes limit the use of farm machinery and make it difficult to farm terraces and to maintain grassed waterways.

These soils are best suited to wheat, clover, alfalfa, and other close-growing crops. They are suited to only limited use for clean-cultivated row crops, such as corn and grain sorghum. Unless management is intensive, these soils are best suited to permanent grass. At present, many areas are in grass.

Terracing, constructing grassed waterways, and farming on the contour help to control runoff and erosion. Residue management, fertilization, and timely tillage help to control runoff, conserve moisture, and maintain soil structure and good tilth.

CAPABILITY UNIT IVe-4

This unit consists of deep and moderately deep, well-drained, gently sloping to strongly sloping, severely eroded soils of the Benfield, Kipson, Pawnee, Mayberry, and Wymore series. These soils have a thin surface layer of silty clay loam, clay loam, silty clay, or clay that is moderately low in organic-matter content. The subsoil is silty clay or clay.

Available water capacity is high in the Wymore soil and moderate in the rest. Permeability is slow. Water runs off during rainstorms, and unless protected, these soils are subject to further erosion. These soils are difficult to work and to keep in good tilth. They are sticky when wet and very hard when dry. Tillage extends into the clayey subsoil. The chief concerns in management are controlling water erosion and improving tilth.

These soils are best suited to such close-growing crops as wheat and legumes. Grain sorghum is the best row crop, but its inclusion in the cropping system should be limited. Unless management for cultivated crops is intensive, these soils are better suited to permanent grass. At present, some areas are in grass.

Terracing, constructing grassed waterways, and farming on the contour help to control runoff and erosion. Crop residue management, timely tillage, and fertilization are needed to help control erosion and to improve organic-matter content, tilth, and fertility. Barnyard manure, green manure crops, and suitable plant population according to soil moisture and fertility also help to improve these soils.

CAPABILITY UNIT IVe-8

This unit consists of deep, well-drained, sloping to moderately steep, eroded and severely eroded soils of the Ida, Monona, Morrill, and Geary series. These soils have a thin surface layer of silt loam, silty clay loam, loam, or clay loam that is moderately low or low in organic-matter content. The subsoil is silt loam, silty clay loam, or clay loam.

Permeability is moderate or moderately slow, and available water capacity is high. Permeability and porosity, or the moisture-air relationship, favors plant growth. These soils have good workability, but the steep slopes and the erosion hazard limit their use for cultivated crops. The soils respond well to good management.

These soils are best suited to wheat, legumes, and other close-growing crops. Their use is limited for row crops of grain sorghum, soybeans, or corn. A suitable cropping system provides a crop or stubble cover two-thirds to three-fourths of the time. Unless these soils are in a suitable crop rotation and under good management, they are best suited to permanent grass.

Terracing, farming on the contour, managing residue, and sodding waterways help to control runoff and erosion. Adding commercial fertilizer and green manure and managing crop residue increase organic-matter content and fertility.

CAPABILITY UNIT IVs-1

The only soils in this unit are in the Slickspots-Wabash complex. These are deep, nearly level, clayey soils that are slightly acid to very strongly alkaline. They are on bottom land. The surface layer is silty clay loam or silty clay, and the subsoil is silty clay. A thin white crust forms on the surface of the Slickspots.

Permeability is very slow or slow, and available water capacity is low or moderate. These soils have poor tilth and are difficult to work. They are sticky when wet, and they dry slowly during rainy periods. During dry periods they are very hard. The major concerns in management are improving drainage and tilth and maintaining a balance of soil moisture and fertility by establishing a suitable cropping system.

These soils are best suited to wheat, grain sorghum, and alfalfa. Wheat is a cool-season crop that utilizes moisture from rains early in spring and moisture stored in the soil during the previous season. The soils can be tilled and seed planted during mild fall weather. Sorghum tolerates dry periods in summer. Alfalfa has deep tap roots that help open the soil and allow water to penetrate more easily. Some areas are used for grass.

Correct row direction, surface bedding, and land grading and leveling improve drainage. Barnyard manure, crop residue, and green manure crops improve tilth and conserve moisture. Additions of such chemicals as gypsum can be used on an experimental basis. Unless management is intensive these soils are best suited to permanent grass or wildlife habitat.

CAPABILITY UNIT IVs-5

Sarpy loamy fine sand is the only soil in this unit. It is a deep, excessively drained, nearly level and very gently undulating soil on bottom land along the Missouri River. The texture of the surface layer and underlying material is loose loamy fine sand.

Permeability is rapid, available water capacity is low, and the organic-matter content is low. The main concern in management is a deficiency of available moisture. Soil blowing and fertility are also concerns.

This soil is best suited to grain sorghum, clover, wheat, and alfalfa. Grain sorghum tolerates dry periods and produces a short stubble residue. Once established, clover and alfalfa have root systems that utilize moisture from deep zones. Wheat produces a close stubble residue. The smaller tracts are suitable for soybeans and corn during years of favorable moisture. Soybeans grow fairly well, but tend to loosen the soil. Little crop residue remains if they are planted continuously. Generally, the droughty nature of the soil affects corn.

Crop residue management, minimum tillage, and fertilization are the principal management practices that help to conserve moisture, increase fertility, and prevent soil blowing. The use of barnyard manure, green manure crops, and winter cover crops also increase organic-matter content and fertility. Under intensive management, more years of row crops can be included in the cropping system.

CAPABILITY UNIT Vw-1

This unit consists of Wet alluvial land, a land type that is very poorly drained. This land occupies shallow depressions or basins in the bottom land and on foot slopes where underground water flows to the surface as springs. Soil material varies in texture, but is mainly silt loam, silty clay loam, and silty clay.

The water table fluctuates within a depth of 3 feet. Excess water is difficult or impractical to remove and is a concern in management. Runoff from adjacent areas during periods of heavy rain is a hazard.

This land is too wet for crops. It is suited to such water-tolerant grasses as prairie cordgrass, reed canarygrass, and tall wheatgrass and is used for hay, permanent pasture, and wildlife. It is also suited to water-tolerant trees and shrubs. Sites are available for the construction of dugouts or collecting basins as a source of water for livestock or wildlife.

Seeding suitable grasses and controlling grazing are necessary management practices in areas used for pasture or hay. Boggy conditions develop in pastures that are grazed when the water level is at the surface. Grazing can be restricted during winter and early spring. Some of the wetter areas that contain sedges and cattails are suitable for tree and shrub plantings. They are also suitable as wildlife habitat. These areas can be fenced off from livestock.

CAPABILITY UNIT VIe-1

The only soil in this unit is Monona silt loam, 17 to 30 percent slopes. It is a well-drained, moderately sloping to steep, slightly eroded soil.

Permeability is moderate, and available water capacity is high. The steep slope is the dominant consideration in use and management. The main concerns are controlling runoff and erosion and preserving or replacing plants used for grazing by livestock.

This soil is too steep and erodible for cultivated crops, but it can be tilled by machinery to establish a permanent cover of native grasses. The most important grasses are big bluestem, indiangrass, prairie dropseed, switchgrass, Canada wildrye, and little bluestem. This soil is also suited to trees and shrubs for windbreak plantings and to wildlife.

In some places, trees and shrubs are the dominant plants. Drainageways provide sites for building stockwater dams and farm ponds.

Seeding suitable grasses, controlling woody plants, and controlling grazing are good management practices for pasture or hayland. Vigor of the desirable prairie grasses can be maintained under good management. The areas most suitable for wildlife are undisturbed or are fenced from livestock.

CAPABILITY UNIT VIe-8

Ida silt loam, 17 to 30 percent slopes, eroded, is the only soil in this unit. It is a deep, well-drained, steep soil on uplands. The surface layer is thin and moderately low in organic-matter content. The underlying material is very friable silt loam.

Permeability is moderate, and available water capacity is high. Permeability and porosity, or the moisture-air relationship, provides a good medium for plant growth. Runoff is rapid, however, and the erosion hazard is severe. Establishing a new permanent cover, reviving existing plants, and maintaining plants that are grazed by livestock are essential in management.

This soil is too steep and erodible for cultivated crops, but it can be tilled for seeding to native grasses. Important grasses are little bluestem, big bluestem, and switchgrass. This soil is also suited to trees and shrubs for windbreaks or for wildlife. Drainageways provide suitable sites for stockwater dams and farm ponds.

Seeding suitable grasses, controlling woody plants, and controlling grazing are essential practices for pastures and hayland. Under good management, the vigor of the choice prairie grasses is maintained. Farm ponds and undisturbed areas can be set aside for wild birds and animals. Areas can be fenced, if necessary, to prevent trampling by livestock.

CAPABILITY UNIT VIs-4

Kipson-Benfield silty clay loams, 9 to 17 percent slopes, are the only soils in this unit. These well-drained to somewhat excessively drained soils are on uplands. The surface layer is silty clay loam, and the subsoil is silty clay loam or silty clay. The shallow Kipson soil and the moderately deep Benfield soil formed in silty to clayey shale.

Permeability is moderately slow to slow, and available water capacity is low or moderate. The organic-matter content is moderate, and natural fertility is medium to high. Runoff is rapid.

The Kipson soil and similar soils make up about 50 percent of the acreage in this unit. These droughty soils largely determine the use and management of soils in this unit. In many places bedrock is at the surface. Keeping the grasses vigorous and productive is the principal concern of management.

These soils are best suited to grass, and most of the acreage is used for this purpose. They are also suited to windbreak plantings and wildlife.

Areas that are cultivated can be seeded to a mixture of native grasses. Grazing can be controlled so that at least half of each year's growth is left on the surface as mulch. This helps to maintain an adequate cover. Spraying helps to control weeds and brush.

CAPABILITY UNIT VIw-1

This unit consists of Silty alluvial land, a frequently flooded land type that occupies narrow bottom lands next to stream channels. Soil material is deep and stratified and is mainly silt loam, loam, very fine sandy loam, and silty clay loam.

In most places the water table is below a depth of 5 feet. Generally, the soil material is fertile, but overflow is frequent. In addition, crooked stream channels make farming impractical. Concerns in management are establishing and caring for permanent plants.

Silty alluvial land is suited to native grasses, mainly big bluestem, indiangrass, prairie cordgrass, and switchgrass. It is also suited to trees and shrubs used for windbreaks or shelter for livestock, to woodlots for lumber, and to wildlife. Sites are available for dugouts or collecting basins as watering places for livestock or wildlife.

Seeding grasses, controlling grazing, and controlling weeds and brush are good management practices for maintaining pastures. Windbreaks, wooded areas, and areas for wild birds and animals can be fenced, if necessary, to prevent trampling and browsing by livestock.

CAPABILITY UNIT VIIe-1

This unit consists of Rough broken land on very steep hills and bluffs along the Missouri River Valley. The soil material is mainly deep silt loam. Outcrops of limestone and shale occur at the lower elevations. Slopes break abruptly to many small drainageways.

The soil material provides a good medium for plants. Runoff is very rapid, and the erosion hazard is severe. Concerns in management are establishing and maintaining new plants for permanent cover and reviving existing plants.

This land area is suited to grasses, trees, and shrubs. It is too steep for tillage by farm machinery. Important grasses are big bluestem and indiangrass. The natural plant community formerly consisted of grasses on the upper slopes and trees in the coves next to the small drains, but trees and shrubs are now the dominant plants. These areas are excellent for wild birds and animals, poor to fair for woodland, and poor for pasture. A few sites are suitable for small dams.

Areas used for wildlife or wooded areas can be fenced from the trampling and browsing livestock. Controlled grazing is a good management practice for pastures. Care is needed in selecting sites for building small dams.

CAPABILITY UNIT VIIs-3

The only soils in this unit are in the Kipson-Sogn complex, 3 to 30 percent slopes. These are somewhat excessively drained, shallow soils over shale or limestone. They have a surface layer of silty clay loam, but in places outcrops of rock or limestone fragments are on the surface.

Permeability is moderate above the shallow bedrock. Available water capacity is low or very low. If these soils are not well managed, runoff is rapid. Reviving and maintaining the most desirable plants that now exist are concerns in management.

These soils are suited only to grasses and trees and are used for pasture, hayland, and wildlife. They are too steep and have too many outcrops to be tilled by farm machinery. Little bluestem, big bluestem, prairie dropseed, and switchgrass are the best suited native grasses. The plant community in most areas consists of some native grasses, some tame grasses, patches of shrubs, and introduced species of Osage-orange and locust trees. In places a few hardwood trees are next to drains on the deeper soils. In some drainageways, suitable sites are available for dams and farm ponds for water for livestock.

Controlling grazing is the main management practice needed for pastures. Establishing the most desirable grasses and controlling woody plants are also needed. Under good management, the vigor of the choice prairie grasses is maintained. Farm ponds and areas set aside for use by wild birds and animals can be fenced or kept from livestock. Care is needed in selecting sites for building farm ponds.

CAPABILITY UNIT VIIIe-1

This unit consists of Gullied land, a land type of gullied drainageways in various kinds of soil material.

Runoff is very rapid, and the nearly vertical slopes are eroding. Some very steep slopes are stabilized. Concerns in management are controlling erosion and preventing injury to people and livestock.

This land is not suited to pasture or woodland, but it is suited to wildlife. It is suited to grasses, trees, or shrubs that establish and survive naturally, and in places it is suited to hand plantings. Good sites for gully control structures are commonly lacking.

Terraces and diversion embankments on cultivated soils that lie upslope help to prevent runoff into these areas. Strips of grass, trees, or shrubs, 50 to 100 feet wide, along the outer edges of these areas keep farm machinery at a safe distance. Once established, plants help to prevent erosion and provide habitat for wildlife. Gullied areas in pastures can be fenced to keep livestock at a safe distance. Fences placed some distance upslope help to control runoff by protecting vegetation from trampling and grazing.

Estimated Yields

Table 2 shows the estimated average acre yields of the principal crops grown in the county under two levels of management. These estimates are based mainly on information obtained from farmers, agricultural workers, and others who have observed yields. The yields are averages for the most recent 5-year period. During favorable years, the yields of dryfarmed crops are higher than those listed in the table. Yields are lower than those listed for all crops when crops are damaged by hail or other natural causes.

Yields in columns A are those obtained under a system of management that does not include regular cropping systems, improved tillage methods, or the adequate use of lime, fertilizer, and crop residue.

Yields in columns B are obtained under management that includes the use of suitable crop varieties, adequate amounts of fertilizer, improved tillage methods, regular improved cropping systems, green manure crops, crop residue, methods to control insects and weeds, and other practices for soil and water conservation.

Yields are particularly useful in comparing one soil with another and in comparing different crops for each soil. Management requirements to maintain a soil, the degree of use, and the input costs are factors to be taken into consideration when comparing yields.

Management of the Soils for Range [4]

The acreage of range, or native grassland, is very small in Richardson County. Generally, it is in small tracts and not suitable for cultivation. The success of the range program depends on management of the grass and feed reserves.

It is important to the livestock farmer to know that different kinds of range produce different kinds and amounts of native grass. Range can be managed properly if the farmer knows the kinds of sites on his range (fig. 13) and the kinds of plants that are suitable to each site. Management can then favor the growth of the best forage plants on each site and maintain the condition of the range. Controlled grazing is the most important practice.

One practice that improves range condition is range seeding. This is the establishment of native grasses by seeding tracts bare of vegetation, or reseeding tracts that are used for range but have an undesirable plant population. Either native grass seed that originates from the same general locality or seed of adapted improved varieties is suitable. Ida silt loam, 17 to 30 percent slopes, eroded; Kipson-Benfield silty clay loams, 9 to 17 percent slopes; and Monona silt loam, 17 to 30 percent slopes, are especially well suited to perennial grasses. They can be seeded to a mixture of native warm-season grasses, consisting of big bluestem, little bluestem, indiangrass, switchgrass, and side-oats grama. No care other than management of grazing is needed to maintain forage composition.

The mapping units in each range site are shown in the "Guide to Mapping Units" at the back of this survey.

Management of the Soils for Windbreaks [5]

Most of the trees and shrubs planted in Richardson County are for farmstead windbreaks. Because some soils are more suited to trees than other soils, and because some species of trees grow better than others on the same soil,

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[4] Prepared by PETER N. JENSEN, range conservationist, Soil Conservation Service.

[5] By JAMES W. CARR, JR., forester, and HOWARD E. SAUTTER, soil scientist, Soil Conservation Service.

TABLE 2.—*Estimated average acre yields of principal crops*

[Yields in columns A are those expected when all practices for a high level of management are not carried out; yields in columns B are those expected under a high level of management. Dashed lines indicate the crop is not suited to the soil or that it is grown only in very small amounts. Only arable soils are listed]

Soil	Corn		Grain sorghum		Wheat		Soybeans		Alfalfa hay	
	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*
Albaton silty clay	50	75	60	85	20	30	25	35	------	5.0
Benfield silty clay loam, 3 to 9 percent slopes, eroded	35	60	50	70	20	25	20	30	2.0	3.5
Benfield-Kipson silty clay loams, 3 to 9 percent slopes, severely eroded	30	50	40	60	15	20	15	25	1.5	3.0
Geary silty clay loam, 5 to 12 percent slopes, eroded	40	70	50	80	20	30	------	------	2.5	4.0
Geary silty clay loam, 5 to 12 percent slopes, severely eroded	35	60	40	70	15	25	------	------	2.0	3.5
Haynie silt loam	65	100	75	110	25	32	25	40	------	5.0
Haynie and Albaton soils	55	85	70	95	25	30	25	30	------	4.5
Haynie and Sarpy soils	55	85	65	90	20	30	20	30	------	4.5
Hobbs silt loam	70	105	75	105	20	30	25	40	------	5.0
Ida silt loam, 12 to 17 percent slopes, eroded	40	65	50	70	------	------	------	------	2.5	3.5
Judson silt loam, 1 to 4 percent slopes	70	100	65	100	30	40	30	40	3.5	4.5
Kennebec silt loam	80	115	75	115	25	35	30	40	------	5.0
Marshall silty clay loam, 0 to 2 percent slopes	65	95	75	100	30	35	30	40	3.5	4.5
Marshall silty clay loam, 2 to 5 percent slopes	60	90	70	95	27	35	25	35	3.2	4.0
Marshall silty clay loam, 5 to 12 percent slopes, eroded	55	80	65	85	25	35	22	30	3.0	4.0
Marshall silty clay loam, 5 to 12 percent slopes, severely eroded	50	75	60	80	22	35	18	25	2.5	3.5
Monona silt loam, 1 to 5 percent slopes	70	95	75	100	30	40	30	40	3.8	5.0
Monona silt loam, 5 to 12 percent slopes	63	85	65	90	25	35	25	38	3.0	5.0
Monona silt loan, 5 to 12 percent slopes, eroded	55	80	60	85	22	30	22	30	2.5	4.5
Monona silt loam, 12 to 17 percent slopes	50	70	55	75	20	27	------	------	2.5	4.0
Monona silt loam, 12 to 17 percent slopes, eroded	45	70	50	75	18	25	------	------	2.0	4.0
Morrill soils, 5 to 12 percent slopes, eroded	40	70	45	75	23	30	22	30	2.0	3.5
Morrill soils, 5 to 12 percent slopes, severely eroded	30	60	40	65	15	25	------	------	1.5	3.0
Morrill soils, 12 to 17 percent slopes	30	45	40	55	15	20	------	------	1.5	3.0
Nodaway silt loam	65	105	75	110	25	35	30	40	------	5.0
Onawa silty clay	55	85	60	90	22	30	25	35	------	4.5
Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded	40	60	50	70	20	30	20	30	2.3	3.0
Pawnee and Mayberry clay loams, 9 to 12 percent slopes, eroded	35	50	40	60	20	25	------	------	2.0	2.5
Pawnee and Mayberry clay loams, 3 to 12 percent slopes, severely eroded	25	40	40	55	18	25	------	------	1.5	2.5
Sarpy loamy fine sand	40	60	45	70	15	20	20	25	------	3.5
Sharpsburg silty clay loam, 0 to 2 percent slopes	65	90	75	95	28	35	28	35	3.5	5.0
Sharpsburg silty clay loam, 2 to 5 percent slopes, eroded	60	80	60	85	25	35	25	35	3.0	4.5
Sharpsburg silty clay loam, 5 to 12 percent slopes, eroded	55	75	65	80	22	27	22	30	2.5	4.0
Sharpsburg silty clay loam, 3 to 12 percent slopes, severely eroded	45	70	50	75	20	25	20	30	2.0	4.0
Slickspots-Wabash complex	20	40	40	50	15	20	15	25	1.5	3.0
Wabash silty clay loam	50	80	60	90	25	30	25	35	3.5	4.5
Wabash silty clay	40	65	45	75	22	28	22	30	3.0	4.0
Wymore silty clay loam, 0 to 1 percent slopes	53	75	65	85	30	35	30	35	3.5	4.5
Wymore silty clay loam, 1 to 3 percent slopes	50	70	60	80	28	35	25	35	3.0	4.0
Wymore silty clay loam, 3 to 9 percent slopes	50	65	55	75	28	32	25	32	3.0	4.0
Wymore silty clay loam, 3 to 9 percent slopes, eroded	45	60	50	75	23	32	22	32	2.5	4.0
Wymore silty clay loam, 9 to 12 percent slopes, eroded	35	55	45	60	20	25	20	28	2.5	3.5
Wymore silty clay loam, 3 to 12 percent slopes, severely eroded	30	50	40	60	18	25	15	23	2.0	3.0
Zook silty clay loam	60	95	70	100	25	30	20	30	3.5	4.5

it is practical to group the soils according to characteristics that affect tree growth. Each soil or mapping unit in the county is assigned to a windbreak group and is listed in the "Guide to Mapping Units" at the back of this survey.

In the following paragraphs is a description of each windbreak group. Mentioned in each description are the kinds of soils, the principal hazards and limitations for planting trees and shrubs, and the trees and shrubs suitable for planting.

SILTY TO CLAYEY WINDBREAK GROUP

This group consists of deep and moderately deep, well drained and moderately well drained soils of the Benfield, Geary, Ida, Judson, Kennebec, Marshall, Monona, Morrill, Nodaway, Pawnee, Mayberry, Sharpsburg, and Wymore series. Judson soils are on foot slopes and Kennebec and Nodaway soils are on bottom lands. The rest are on uplands.

Because Judson, Kennebec, and Nodaway soils have slow or medium runoff, moderate permeability, and high

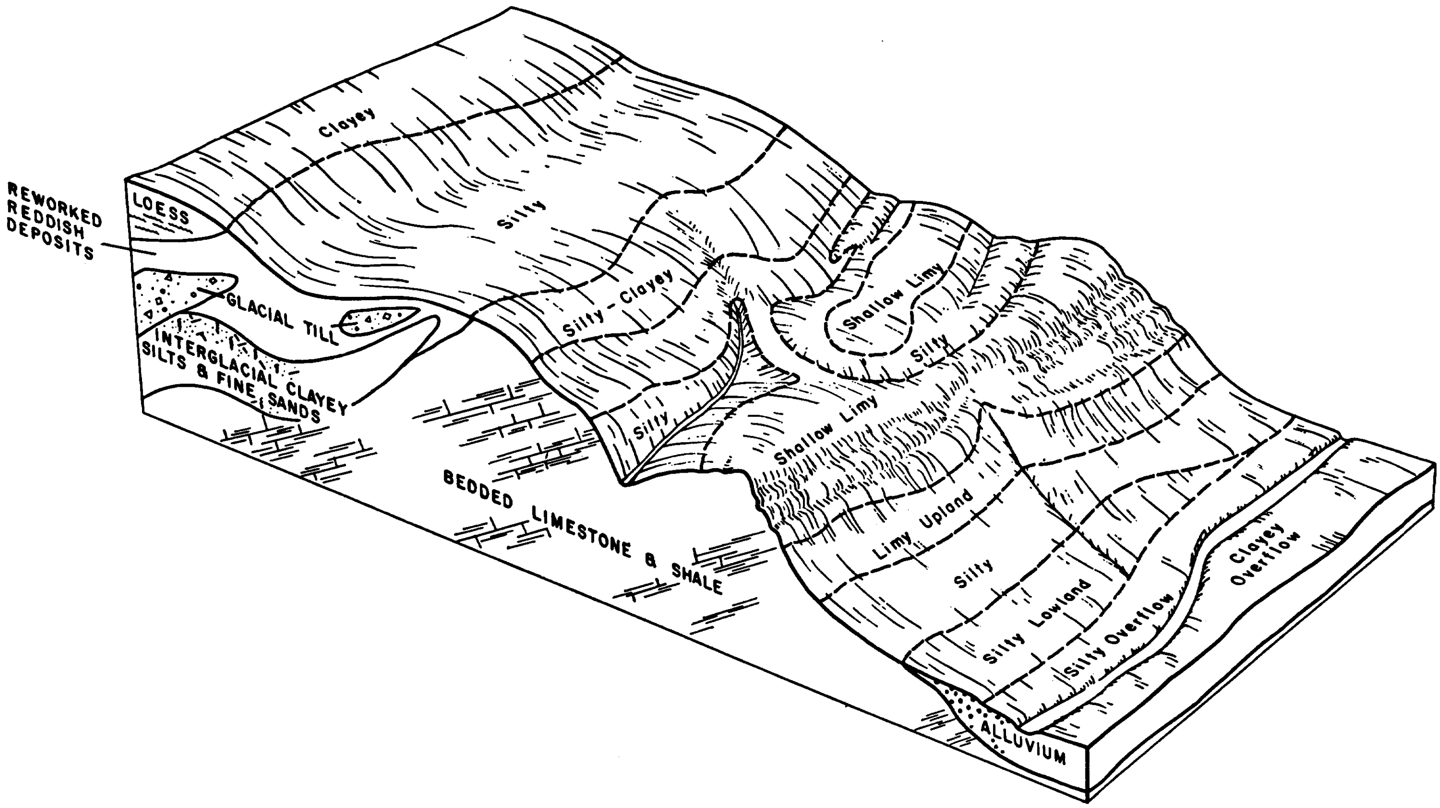

Figure 13.—Distribution of range sites on typical landscape of Richardson County.

available water capacity, and because they receive runoff from higher slopes, the mature height of trees on these soils is slightly more than that of trees on the soils in the uplands.

The Benfield, Pawnee, and Mayberry soils are on uplands and have a silty clay or clay subsoil. They are somewhat droughty because permeability is slow and available water capacity is only moderate. Moisture does not penetrate their subsoil easily. It is held tightly and is less available for plant use than in other soils in the group. For this reason, establishing tree seedlings is more difficult on Benfield, Pawnee, and Mayberry soils than on other soils in the group. The rest of the soils in this windbreak group have moderate, moderately slow, or slow permeability and high available water capacity.

All the soils in this group are suited to windbreak plantings. Species that do well on these soils are conifers, such as eastern redcedar, ponderosa pine, Austrian pine, Scotch pine, eastern white pine, and Norway spruce; broadleafs, such as green ash, hackberry, and bur oak; and shrubs, such as cotoneaster, honeysuckle, and lilac.

Measurements of trees on soils in this group indicate that at 20 years of age, eastern redcedar averages about 21 feet in height; ponderosa pine, 25 feet; green ash, 22 feet; honeylocust, 34 feet; hackberry, 26 feet; and Russian-olive, 19 feet.

Tracts of natural woodland occur on the moderately steep and steep Ida and Monona soils and on Rough broken land. These soils are in the extreme eastern part of the county and originally supported vegetation of the oak-hickory forest type (*4*). This forest type included several species of oak and hickory, and also hackberry, black cherry, American elm, slippery elm, and black walnut. The best trees of the most desirable species were harvested from these stands. Thus, the present stand is one of defective trees of low-value species. If reforested and well managed, many of these tracts could support trees of value for wood crops, recreation, and wildlife.

MODERATELY WET WINDBREAK GROUP

This group consists of Silty alluvial land and deep, moderately well drained, somewhat poorly drained and poorly drained soils of the Albaton, Haynie, Hobbs, Onawa, Wabash, and Zook series. These soils are on bottom land.

Haynie and Hobbs soils have a loamy texture throughout the profile. They have moderate permeability and high available water capacity, but are subject to occasional flooding. Moisture penetrates these soils readily, and tree seedlings are easier to establish than on the rest of the soils in this group. Because of additional moisture, tree growth is rapid.

Wabash, Albaton, and Onawa soils have a clayey texture. Permeability is slow, and water on the surface drains slowly. Wetness is a limitation. Silty alluvial land occupies narrow flood plains of meandering streams and is subject to frequent flooding.

The soils in this group are suited only to windbreak plantings that tolerate occasional wetness. Windbreaks are rarely established in this group, but it is one of the best planting sites for black walnut in the county. In areas where black walnut and other desirable species are planted or managed for a wood crop, exclusion of livestock is necessary. Suitable broadleaf trees are green ash, cottonwood, white willow, sycamore, and black walnut. Suitable conifers are eastern redcedar and Scotch pine. Shrubs that do well on these soils are eastern chokecherry, Nemaha plum, and red-osier dogwood.

Trees of the northern flood plain forest (*4*) grew naturally on bottom land soils along the Missouri River. These trees were cottonwood, ash, elm, willow, sycamore, and maple. For the most part, these areas have been cleared of trees and are now farmed.

VERY WET WINDBREAK GROUP

Only Wet alluvial land, a land type of varying textures of deep alluvium, is in this group. It occupies small tracts on bottom land and is suited only to trees tolerant of extreme wetness. Water is at or near the surface during most of the year. Golden willow, diamond willow, white willow, cottonwood, and red-osier dogwood are best suited. Wetness interferes with preparing the soil for planting. A good method of planting on these sites is to plant the trees in a furrow 18 to 20 inches wide, and just deep enough to scalp the sod. In places, seedlings have to be hand planted.

SANDY WINDBREAK GROUP

This group consists of deep, excessively drained Sarpy loamy fine sand on high bottom land along the Missouri River. Because the water table is at a depth of about 10 to 15 feet, and permeability is very rapid, tree growth is good. However, low available water capacity and soil blowing make it difficult to establish tree seedlings. Eastern redcedar, ponderosa pine, and Scotch pine are examples of trees well suited to this soil for use as windbreaks. Cottonwood, once established, also does well on this soil. Originally, vegetation of the northern flood plain forest type (*4*) grew on this soil, but it has long since been cleared, and most of the acreage is now farmed.

MODERATELY SALINE OR ALKALI WINDBREAK GROUP

This group consists of soils in the Slickspots-Wabash complex. These soils are in intermittent areas of bottom land along the Nemaha River and Muddy Creek. Slickspots are strongly alkaline. Wabash soils are poorly drained and have a silty clay loam or silty clay surface layer and silty clay underlying material. Permeability is very slow or slow, and water on the surface drains slowly.

Because this site is wet during rainy periods and droughty during dry periods, tillage and establishment of tree seedlings are difficult. The soils are suited to trees tolerant to moderate concentrations of salts or alkali. Conifers suited to windbreak plantings are eastern redcedar and ponderosa pine. Broadleafs suited to windbreak plantings are diamond willow, green ash, and cottonwood. Buffaloberry is a shrub that does well.

SHALLOW WINDBREAK GROUP

This group consists of soils in the Kipson and Sogn series. These soils are shallow over shale and hard limestone. They occupy uplands along the drains to the Nemaha River in the western part of the county. They are somewhat excessively drained and have very low to low available water capacity.

Kipson soils are better suited to trees than Sogn soils because tree roots can penetrate the underlying shale for nutrients and moisture. Because the Sogn soils are shallow over limestone, tree establishment is marginal. In places small areas of moderately deep Benfield soils and patches of deep Judson and Wymore soils are on ridgetops or along upland drainageways. On these deeper soils, tree growth is much better than on the shallow soils of this group.

These soils are best suited to eastern redcedar for windbreak plantings. Annual growth and height at maturity are considerably less for trees planted on soils of this group than on soils of the other groups in the county. Where possible, trees are planted on the contour.

The original vegetation was probably native prairie and a few oak trees. Overgrazing of the grasses and absence of natural fires encouraged the encroachment of brush and introduced such trees as honeylocust and Osage-orange.

UNDESIRABLE WINDBREAK GROUP

This group consists of Gullied land and Rough broken land, both of which are so steep that tree plantings are impractical and cannot be expected to succeed.

Because of unfavorable qualities and characteristics, the soils of this group are not generally suited to windbreak plantings of any kind. Some areas can be used for recreational purposes, wildlife, or trees and shrubs that are planted by hand.

Management of the Soils for Wildlife and Recreation [6]

Wildlife management requires a knowledge of soils, the climate, and the kind of vegetation the soils are capable of producing. The kind, amount, and distribution of vegetation largely determines the kind and amount of wildlife that can be produced and maintained.

Fertility, permeability, and other soil characteristics affect the wildlife carrying capacity of an area. Fertile soils generally produce more wildlife than infertile soils, and waters drained from fertile soils generally produce more fish than waters drained from infertile soils.

Topography affects wildlife by influencing land use. Steep or rough, irregularly shaped tracts are hazards to livestock and are impractical to farm. Undisturbed vegetation on these sites is valuable as food and as protective cover for wildlife. Large open areas of nearly level and gently sloping soils lack the undisturbed vegetative cover if they are farmed, but provide additional food necessary for certain species of wildlife in the form of seeds left as waste.

Permeability and the rate of water infiltration affect surface runoff and water turbidity and are important soil characteristics in the retention of water for fish-

[6] By R. J. LEMAIRE, biologist, and HOWARD SAUTTER, soil scientist, Soil Conservation Service.

ponds and in the development and maintenance of habitat for waterfowl. Marshy areas are suitable for the development of habitat for waterfowl and some species of aquatic and semiaquatic furbearers.

The soils of Richardson County provide suitable habitat for a variety of game and nongame birds and mammals. The suitability of the soils for various types of wildlife and the potential of the soils for recreational uses are defined, by soil association, in the following paragraphs. For detailed descriptions of each soil association, refer to the section "General Soil Map."

Wooded tracts on the bottom land of the Haynie-Albaton association and the Kennebec-Judson-Wabash association provide habitat for songbirds and several types of game birds and animals. Included are deer, bobwhite quail, squirrel, and cottontail rabbit. Mink, muskrat, beaver, and other furbearers that require wet areas are also found in these associations. Water is sometimes scarce for these furbearers, but habitat is abundant for others, such as raccoon, opossum, and coyote. During spring and fall migration periods, water and marsh areas are used by waterfowl.

The most important fishery in Richardson County is in the Big Nemaha River and its tributaries in the Kennebec-Judson-Wabash association and in the Missouri River in the Haynie-Albaton association. These major streams in the county are suitable for the development of water recreational areas, but the soils in these areas are among the poorest in the county for building sites or for developing outdoor recreational activities. Poor drainage and the hazard of flooding are among the limiting factors to be considered when developing recreational sites. Sites of historic interest in these areas and in the rest of the county add to the potential for the development of recreational facilities.

Soils on uplands in the Monona association, in the eastern part of Richardson County, are rated poor to good for producing grain and seed for wildlife. These ratings reflect the steepness of slope and the use of the soils. Very gently sloping to strongly sloping soils that are farmed are rated good. Moderately steep and steep soils that are used mainly for pasture or trees are rated poor. The steeper soils are in the northern and eastern part of the association, and the more moderately sloping soils are in the western and southern part. The wooded tracts in the steeper part of the association provide habitat for songbirds, quail, deer, squirrel, cottontail rabbit, and upland furbearers, such as raccoon, opossum, and coyote. Slope is a moderate to severe limiting factor, and erosion is a moderate to severe hazard to the development of recreational sites on soils of the association.

The Marshall-Sharpsburg association is in the central part of the county and extends north into Nemaha County, Nebraska, and south into Kansas. It is on uplands and provides a varied topography and habitat for wildlife. The many small streams and draws that dissect this association provide numerous areas of relatively undisturbed shrubby, grassy, and herbaceous vegetation that is important for many kinds of wildlife. The small stream valleys that drain this association generally are wooded and provide habitat for squirrel, bobwhite quail, mourning dove, cottontail rabbit, deer, and a number of other animals and birds. Slope is a slight to moderate limiting factor, and erosion is a slight to moderate hazard to the development of recreational sites on soils of the association.

The Wymore association on uplands in the western part of the county is scored with small waterways and draws. Compared with counties in central and northeastern Nebraska, Richardson County has a small pheasant population, but the greatest density of this small population is in the northwestern corner of the county in the largest expanse of the Wymore association. Waste from grain sorghum and corn provides an excellent supply of food for pheasant, and wheat and clover provide nesting areas. Slope is a slight to moderate limiting factor, and erosion is a slight to moderate hazard to the development of recreational sites on soils of this association.

Soils in the Morrill-Pawnee-Mayberry association formed mainly in glacial materials. Because of their position on the landscape, they usually occur in strips and rarely in large areas. Many irregularly shaped areas that have natural grass vegetation are interspersed with cultivated tracts and woody draws, producing desirable mixture of habitat requirements for the important game species and many other kinds of wildlife. Slope and soil texture are moderately to severely limiting, and erosion is a moderate to severe hazard to the development of recreational sites on soils of this association.

The Kipson-Benfield-Sogn association occurs mainly in the western and southern parts of the county at high elevations in the uplands and on valley sides of the Nemaha River. The soils provide a variety of wildlife habitat. Vegetation is mostly grasses and introduced species of trees and shrubs. Some of the moderately deep, sloping Benfield soils are cultivated, and waste from farm crops provides food for wildlife. Wildlife cover provided by grasses and woody vegetation and food provided by seed and grain crops is a desirable combination for producing wildlife populations. The important game species include deer, quail, squirrel, and cottontail rabbit. Slopes are moderately to severely limiting, and the hazard of erosion is severe to the development of recreational sites on soils of the association.

All the soil associations in the county but the Haynie-Albaton and the Kennebec-Judson-Wabash soil associations have sites suitable for the building of dams for fishponds. These ponds are suitable only for bass, bluegill, channel catfish, and other warm-water fish. Turbidity is a limitation in some of these ponds, particularly in areas where there is little conservation treatment above the pond, and in watershed areas where soils are high in clay content but low in calcium carbonate content.

Table 3 shows the suitability of the soil associations for producing various types of vegetation that are significant to the habitat of the more important game species in Richardson County. The ratings of *well suited*, *suited*, *poorly suited*, and *unsuited* take into account the characteristics of the soils with respect to their potential for producing the kind of vegetation needed for wildlife habitat. Table 3 also shows the importance of the different vegetation types for food and cover for several game species.

TABLE 3.—*Soil associations rated for major kinds of wildlife habitat, and wildlife habitat rated for kinds of game*

	Suitability for producing—			
	Woody plants	Herbaceous plants	Grain and seed crops	Aquatic habitat
Soil associations:				
1. Haynie-Albaton	Well suited	Well suited	Well suited	Suited.
2. Kennebec-Judson-Wabash	Well suited	Well suited	Well suited	Suited.
3. Monona	Well suited	Well suited	Suited to unsuited [1]	Unsuited.
4. Marshall-Sharpsburg	Well suited	Well suited	Suited	Unsuited.
5. Wymore	Well suited	Well suited	Suited	Unsuited.
6. Morrill-Pawnee-Mayberry	Suited	Suited	Poorly suited	Unsuited.
7. Kipson-Benfield-Sogn	Poorly suited	Poorly suited	Poorly suited	Unsuited.

	Wildlife habitat					
	Woody plants		Herbaceous plants		Grain and seed plants	
Kinds of game:	*Food*	*Cover*	*Food*	*Cover*	*Food*	*Cover*
Bobwhite quail	Low	High	High	High	High	Low.
Deer	High	High	Medium	Low	High	Low.
Pheasant	Low	High	High	High	High	High.
Waterfowl					High	

[1] Suited on moderate slopes; unsuited on steep slopes.

Because wildlife is produced on privately owned lands and on soils used primarily for crops, grasses, or woods, the success of wildlife production depends on the farmer's interest and his use and treatment of the land.

Almost every practice that helps to protect and improve soil and to conserve moisture also improves food and cover for wildlife. Improved grass on range and pasture; crop stubble and grass edges in cultivated fields, windbreaks or woods; and control of sedimentation in streams help wildlife directly and are basic measures for conserving soil and water.

Landowners interested in wildlife can develop areas for their own use or for sportsmen. Because hunting, fishing, and other outdoor sports are increasing in popularity, farmers and landowners can use their land profitably for recreational activities. Special areas include marsh development with duck blinds, water development for fishing, upland regions for game hunting, or scenic areas for cabin sites. There are small, irregularly shaped or isolated tracts in almost all areas in the county that are ideal for wildlife development, at least for the individual landowner's enjoyment. However, certain larger tracts would lend themselves to special use areas as an economic investment.

Technical assistance in planning wildlife areas, and assistance in planning and application of conservation practices for developing outdoor recreational facilities can be obtained from the Soil Conservation Service in Falls City, Nebraska. Additional information and assistance can be obtained from the Nebraska Game and Parks Commission, the Bureau of Sports, Fisheries and Wildlife, and from the Federal Extension Service.

Engineering Uses of the Soils [7]

This section is useful to those who need information about the suitability of soils 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 reaction. Also important are depth to the water table, depth to bedrock, and 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.

[7] This section was prepared by MARVIN D. KEEBLER, area engineer, and HOWARD E. SAUTTER, soil scientist, Soil Conservation Service, with the assistance of ROBERT J. FREDRICKSON, civil engineer, Soil Conservation Service, and WILLIAM J. RAMSEY, Division of Materials and Tests, Nebraska Department of Roads.

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.

The engineering interpretations reported here do not eliminate the need for detailed field investigations at the site of specific engineering works. This is particularly important in areas involving heavy loads and where excavations are deeper than the depths of layers here reported. The estimates generally are to a depth of 5 feet, and interpretations normally do not apply to greater depths.

Small areas of other soils are included in the mapping units. The soil map is useful in planning foundation investigations and indicating the kind of problems that may be expected. Most soils of Richardson County are deep enough over bedrock that bedrock does not affect their use with the exception of Kipson, Sogn, and Benfield soils. Interbedded limestone and shale are at depths of 5 to 20 inches in Kipson and Sogn soils. Shale is at a depth of about 40 inches in Benfield soils.

Terms in this publication are those used by soil scientists. Several of these terms are defined in the Glossary. Most of the information in this section is presented in tables 4, 5, and 6, which show, respectively, results of engineering laboratory tests on soil samples; several estimated soil properties significant in engineering; and interpretations for various engineering uses.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 5 and 6, and it also can be used to make other useful maps.

Engineering classification systems

Soils are classified so that people can communicate in common terms. Two systems of soil classification widely used for engineering purposes are described below. These systems are the Unified Soil Classification System (*10*) and the system adopted by the American Association of State Highway Officials (AASHO) (*1*). The relationship between these two classification systems and the USDA textural classification is indicated in table 5.

In the AASHO system, seven groups of soils are classified on the basis of field performance. The groups are classified from A–1, sand and gravel that have a high bearing capacity, to A–7, clay that has low capacity when wet. A–1, A–2, and A–3 soils are mostly sand and gravel mixtures. The probable performance of the soil on the site is indicated by a group index number.

A sand-silt-clay soil is further classified by identifying the silt-clay portion. Thus, an A–2–4 soil is an A–2 sand that has an A–4 type of silt-clay mixture included.

The group index number, shown in parentheses in table 4, ranges from 0 to 20 and is a rating of field performance of the soil. Thus, an A–2–4(0) soil is one of the best for highway construction. A soil that has a group index number of 20 would be one of the least desirable soils for highway location or construction.

The Nebraska Department of Roads uses a group index of −4 to 32 instead of 0 to 20. This enlarged group index bracket allows the plastic and nonplastic fine-grained soil occurring in sands to be evaluated and the effect of a high clay content (group index greater than 20) to be determined.

The Soil Conservation Service, U.S. Bureau of Reclamation, Corps of Engineers, and other organizations and engineers use the Unified System. Soils are generally classified as coarse grained, fine grained, and organic or peat.

Fine-grained soils are classified according to plasticity characteristics. Coarse-grained soils are classified primarily according to gradation, and organic soils are classified according to odor and plasticity change after ovendrying.

Combinations of letters are used to identify soil materials and certain properties in the Unified System. G is used for gravel, S for sand, C for clay, M for silt, W for well graded, P for poorly graded, L for low liquid limit, and H for high liquid limit.

Two letters are combined to classify the soil; for example, SP is a sand that is poorly graded; CL is a clay of low plasticity; and GC is a gravel-clay mixture. There are 12 possible inorganic classifications, and three possible organic classifications. Organic (OL and OH) and peat (Pt) soils are uncommon in Nebraska.

In tables 4 and 5 the soils of Richardson County are classified as SC, SM, ML, ML-CL, CL, and CH. Soils that have borderline characteristics of two classifications are given a dual classification.

Engineering test data

Table 4 shows engineering test data from tests on 32 soil samples representing 11 soil series. These soils represent the most extensive soils in Richardson County, covering about 80 percent of the county. The tests were made by the Division of Materials and Tests, Nebraska Department of Roads, according to standard procedures of the American Association of State Highway Officials.

Each soil listed in table 4 was sampled at only one location, and the data given for the soil are those at the location. From one location to another, a soil can differ considerably in characteristics that affect engineering. Even where soils are sampled at more than one location, the test data probably do not show the widest range in characteristics.

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.

TABLE 4.—*Engineering*

[Tests performed by the Nebraska Department of Roads in cooperation with U.S. Department of Commerce, Bureau of Public

Soil name and location	Parent material	Report No.	Depth	Moisture density [1]		Mechanical analysis [2]	
				Maximum dry density	Optimum moisture	Percentage passing sieve—	
						⅜-in.	No. 4 (4.7 mm.)
			In.	*Lb. per cu. ft.*	*Pct.*		
Benfield silty clay loam: 75 feet west of center of section 25, T. 1 N., R. 13 E. (Modal profile.)	Clayey shale.	S63-8394	0–7	97	23	----------	----------
		S63-8395	16–27	99	24	----------	----------
		S63-8396	40–47	105	21	----------	100
Haynie silt loam: 0.2 mile east of southwest corner of section 15, T. 3 N., R. 17 E. (Modal profile.)	Silty alluvium.	S63-8388	0–7	104	18	----------	----------
		S63-8389	10–30	107	18	----------	----------
		S63-8390	45–55	105	18	----------	----------
Kennebec silt loam: 135 feet north and 0.45 mile west of the southeast corner of section 7, T. 2 N., R. 17 E. (Modal profile.)	Silty alluvium.	S63-8391	0–7	101	20	----------	----------
		S63-8392	12–26	91	27	----------	----------
		S63-8393	44–53	97	22	----------	----------
Marshall silty clay loam: 168 feet south and 0.35 mile west of the northeast corner of section 1, T. 2 N., R. 15 E. (Heavier subsoil than modal profile.)	Loess.	S63-8397	0–6	101	19	----------	----------
		S63-8398	17–31	100	19	----------	----------
		S63-8399	42–50	102	19	----------	----------
Monona silt loam: 125 feet north and 0.1 mile west of the southeast corner of section 22, T. 2 N., R. 17 E. (Modal profile.)	Loess.	S63-8400	0–6	103	20	----------	----------
		S63-8401	19–32	107	18	----------	----------
		S63-8402	45–60	109	18	----------	----------
Morrill clay loam: 180 feet south and 0.13 mile west of the northeast corner of section 21, T. 3 N., R. 13 E. (Modal profile.)	Glacial outwash	S63-8403	0–6	104	16	----------	----------
		S63-8404	25–37	108	15	100	98
		S63-8405	45–53	115	13	100	99
Pawnee clay loam: 320 feet west and 0.3 mile south of the northeast corner of section 24, T. 2 N., R. 14 E. (Modal profile.)	Glacial till.	S63-8406	0–7	106	17	----------	----------
		S63-8407	11–25	99	23	----------	100
		S63-8408	37–50	104	19	100	99
Sharpsburg silty clay loam: 100 feet west and 0.2 mile north of the southeast corner of section 8, T. 2 N., R. 15 E. (Modal profile.)	Loess.	S63-8409	0–7	95	23	----------	----------
		S63-8410	20–30	98	21	----------	----------
		S63-8411	40–55	102	21	----------	----------
Wabash silty clay: 0.5 mile south and 0.12 mile east of the northwest corner of section 2, T. 1 N., R. 15 E. (Modal profile.)	Clay alluvium.	S63-8412	0–7	90	24	----------	----------
		S63-8413	15–30	88	29	----------	----------
Wymore silty clay loam: 95 feet west and 0.25 mile north of the southeast corner of section 9, T. 3 N., R. 13 E. (Modal profile.)	Loess.	S63-8414	0–7	96	20	----------	----------
		S63-8415	18–31	97	23	----------	----------
		S63-8416	45–60	103	21	----------	----------
Zook silty clay loam: 270 feet west of center of section 20, T. 1 N., R. 16 E. (Modal profile.)	Silty to clayey alluvium.	S63-8385	0–6	99	22	----------	----------
		S63-8386	6–25	99	22	----------	----------
		S63-8387	25–38	99	19	----------	----------

[1] Based on AASHO Designation: T 99–57, Method A(*1*).
[2] Mechanical analysis according to AASHO Designation: T 88–57(*1*). Results by this procedure may differ somewhat 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 material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than

test data

Roads (BPR), in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis[2]—Continued							Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued			Percentage smaller than—						AASHO	Unified[3]
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
							Pct.			
----------	100	100	94	72	47	35	45	20	A-7-6(13)	ML-CL.
----------	100	100	95	81	61	52	63	38	A-7-6(20)	CH.
99	97	93	92	84	58	43	49	27	A-7-6(17)	CL.
----------	----------	100	95	47	22	16	38	11	A-6(8)	ML.
100	99	92	86	35	16	16	29	7	A-4(8)	ML-CL.
----------	100	99	94	72	28	21	50	18	A-7-5(13)	ML or MH.
----------	----------	100	93	48	22	17	35	7	A-4(8)	ML.
----------	100	99	94	50	20	16	35	7	A-4(8)	ML.
----------	----------	100	91	76	39	31	48	21	A-7-6(14)	ML-CL.
----------	100	99	92	56	37	32	42	16	A-7-6(11)	ML-CL.
----------	----------	100	97	75	41	33	53	28	A-7-6(18)	CH.
----------	----------	100	96	67	31	26	44	20	A-7-6(13)	CL.
----------	100	99	93	56	30	23	40	15	A-6(10)	ML-CL.
----------	----------	100	91	56	23	20	42	12	A-7-5(9)	ML.
----------	100	99	94	54	22	17	36	12	A-6(9)	ML-CL.
100	93	77	72	53	33	27	37	14	A-6(10)	ML-CL.
97	85	63	61	49	35	29	38	19	A-6(9)	CL.
94	73	47	46	39	30	28	40	23	A-6(7)	SC.
100	96	84	78	56	31	26	37	14	A-6(10)	ML-CL.
99	94	82	77	56	46	42	57	35	A-7-6(19)	CH.
97	89	76	72	65	49	42	57	35	A-7-6(19)	CH.
----------	100	98	91	65	40	33	45	19	A-7-6(13)	ML-CL.
----------		100	94	74	41	33	52	27	A-7-6(17)	CH.
----------	100	99	95	69	37	31	45	20	A-7-6(13)	ML-CL.
----------	----------	100	99	91	66	50	61	32	A-7-6(20)	MH-CH.
----------	100	99	97	89	70	60	86	53	A-7-5(20)	CH.
----------	100	99	93	69	48	40	43	17	A-7-6(11)	ML-CL.
----------	----------	100	95	77	50	44	58	33	A-7-6(20)	CH.
----------	----------	100	96	68	35	24	41	19	A-7-6(12)	CL.
----------	100	98	95	78	42	33	44	20	A-7-6(13)	CL.
100	99	98	92	66	40	30	51	27	A-7-6(17)	CH.
----------	100	99	93	72	46	37	56	35	A-7-6(19)	CH.

2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification. Examples of borderline classifications obtained by this use are SM-SC and ML-SM.

TABLE 5.—*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 referring to other series that appear in the first column of this

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA texture	Unified [1]	AASHO [1]
	Ft.	*In.*			
Albaton: Ak	5–10	0–50	Silty clay	CH or CL	A–7
*Benfield: BfB2, BKB3 For Kipson part of BKB3, see Kipson series.	>20	0–7 7–40 40–50	Silty clay loam Silty clay loam and silty clay. Silty clay loam and clayey shale.	CL or ML CH or CL CL or CH	A–7 or A–6 A–7 A–7
Geary: GeC2, GeC3	>20	0–7 7–60	Silty clay loam Silty clay loam	ML or CL CL	A–6 or A–7 A–7
Gullied land: GL. No valid estimates can be made.					
*Haynie: HA, He, HS For Albaton part of HA, see Albaton series. For Sarpy part of HS, see Sarpy series.	5–15	0–60	Silt loam	ML, ML–CL, or MH.	A–4, A–6, or A–7.
Hobbs: Hv	8–20	0–32 32–60	Silt loam Heavy silt loam	ML or CL ML or CL	A–4 or A–6 A–4 or A–6
Ida: IdD2, IdF2	>20	0–26 26–60	Silt loam Silt loam	ML or CL ML	A–6 A–6 or A–4
Judson: JuA	10–20	0–8 8–22 22–60	Silt loam Heavy silt loam Silty clay loam	ML or CL CL or ML CL	A–6 A–6 A–7
Kennebec: Ke	6–20	0–7 7–38 38–53	Silt loam Silt loam Silty clay loam	ML ML or CL CL or ML	A–4 A–4 or A–6 A–7 or A–6
*Kipson: KBD, KSD For Benfield part of KBD, see Benfield series. For Sogn part of KSD, see Sogn series.	>20	0–12 12–20 20–40	Silty clay loam Silty clay loam Silt loam and clayey shale.	CL CL CL or CH	A–7 A–7 A–7
Marshall: MaA, MaB, MaC2, MaC3	>20	0–12 12–35 35–55 55–60	Silty clay loam Silty clay loam Silty clay loam Silt loam	ML or CL CL or CH CL or ML ML or CL	A–7 or A–6 A–7 A–7 or A–6 A–7 or A–6
Mayberry Mapped only with Pawnee soils.	>20	0–18 18–54 54–60	Clay loam Clay Stratified sandy loam, silty clay loam, and clay.	CL CH or CL CL or CH	A–7 A–7 A–7 or A–6
Monona: MnB, MnC, MnC2, MnD, MnD2, MnF	>20	0–60	Silt loam	ML or CL	A–6 or A–7
Morrill: MC2, MC3, MD	>20	0–6 6–37 37–60	Clay loam Clay loam and gritty clay loam. Gritty clay loam and coarse loam.	CL or ML CL or SC SM or SC	A–6 or A–7 A–6 or A–7 A–6

See footnotes at end of table.

of significance in engineering

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

Percentage of material less than 3 inches passing sieve—				Material finer than 0.002 mm.	Permeability	Available water capacity [2]	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)					
				Pct.	*In./hr.*	*In./in. of soil*	*pH*	
		100	90–100	50–60	0. 06–0. 20	0. 11–0. 13	7. 4–8. 4	High.
		100	95–100	30–45	0. 20–0. 63	0. 21–0. 23	6. 1–6. 5	Moderate to high.
		100	95–100	45–55	0. 06–0. 20	0. 15–0. 17	6. 6–7. 8	High.
100	95–100	90–100	85–95	40–50	0. 06–0. 20	0. 03–0. 05	7. 9–8. 4	High.
		100	95–100	25–35	0. 20–0. 63	0. 21–0. 23	5. 6–6. 0	Moderate to high.
	100	95–100	90–100	25–45	0. 20–0. 63	0. 18–0. 20	6. 1–7. 3	Moderate to high.
	100	95–100	85–100	15–25	0. 63–2. 00	0. 20–0. 22	7. 4–8. 4	Low to moderate.
		100	95–100	14–28	0. 63–2. 00	0. 21–0. 23	6. 1–6. 5	Moderate.
		100	95–100	18–28	0. 63–2. 00	0. 20–0. 22	6. 1–6. 5	Moderate.
		100	98–100	15–25	0. 63–2. 00	0. 21–0. 23	7. 9–8. 4	Moderate.
		100	98–100	15–25	0. 63–2. 00	0. 20–0. 22	7. 9–8. 4	Moderate.
		100	95–100	20–25	0. 63–2. 00	0. 22–0. 24	6. 1–6. 5	Moderate.
		100	95–100	20–28	0. 63–2. 00	0. 20–0. 22	5. 6–6. 0	Moderate.
		100	95–100	25–35	0. 20–0. 63	0. 18–0. 20	6. 1–6. 5	Moderate to high.
		100	95–100	15–20	0. 63–2. 00	0. 22–0. 24	6. 6–7. 3	Moderate.
		100	95–100	15–20	0. 63–2. 00	0. 20–0. 22	6. 1–6. 5	Moderate.
		100	95–100	25–35	0. 20–0. 63	0. 18–0. 20	6. 1–6. 5	Moderate to high.
[3] 70–100	70–100	65–95	60–90	30–45	0. 63–2. 00	0. 21–0. 23	7. 4–7. 8	Moderate to high.
[3] 75–90	75–90	70–90	65–85	30–45	0. 63–2. 00	0. 18–0. 20	7. 9–8. 4	Moderate to high.
[3] 75–90	75–90	70–85	65–80	40–50	0. 06–0. 20	0. 03–0. 05	7. 9–8. 4	Moderate to high.
		100	95–100	25–35	0. 20–0. 63	0. 21–0. 23	5. 6–6. 0	Moderate to high.
		100	95–100	30–40	0. 20–0. 63	0. 18–0. 20	6. 1–6. 5	High.
		100	95–100	20–30	0. 20–0. 63	0. 18–0. 20	6. 6–7. 3	Moderate to high.
		100	95–100	15–25	0. 63–2. 00	0. 20–0. 22	6. 6–7. 3	Moderate.
	100	95–100	80–95	20–35	0. 20–0. 63	0. 17–0. 19	5. 6–6. 0	Moderate to high.
[4] 95–100	95–100	95–100	70–90	35–50	0. 06–0. 20	0. 08–0. 10	6. 1–7. 3	High.
[4] 95–100	95–100	90–100	75–95	30–55	0. 20–0. 63	0. 12–0. 15	6. 1–7. 3	Moderate to high.
		100	95–100	15–25	0. 63–2. 00	0. 20–0. 22	6. 1–7. 8	Moderate.
100	95–100	90–100	60–80	20–35	0. 20–0. 63	0. 17–0. 19	6. 1–6. 5	Moderate to high.
[4] 95–100	95–100	80–95	40–65	25–35	0. 20–0. 63	0. 15–0. 19	6. 1–6. 5	Moderate to high.
[4] 95–100	90–100	70–95	35–50	15–30	0. 63–2. 00	0. 14–0. 16	6. 1–6. 5	Moderate.

TABLE 5.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface (typical profile)	Classification		
			Dominant USDA texture	Unified [1]	AASHO [1]
	Ft.	*In.*			
Nodaway: Nd	8–15	0–10	Silt loam	ML	A–4
		10–60	Silt loam, very fine sandy loam, and silty clay loam.	ML or CL	A–4 or A–6
Onawa: Oc	5–10	0–18	Silty clay	CH or CL	A–7
		18–27	Light silty clay	ML or CL	A–7
		27–50	Silt loam, very fine sandy loam, and silty clay loam.	ML or CL	A–4 or A–6
*Pawnee: PAC2, PAD2, PAD3. For Mayberry part, see Mayberry series.	>20	0–11	Clay loam	CL or ML	A–6 or A–7
		11–37	Clay	CH	A–7
		37–50	Heavy clay loam	CH	A–7
Rough broken land: RB. No valid estimates can be made.	>20				
Sarpy: Sg	6–15	0–50	Loamy fine sand	SM	A–2 or A–4
Sharpsburg: ShA, ShB2, ShC2, ShC3	>20	0–10	Silty clay loam	CL or ML	A–7 or A–6
		10–30	Heavy silty clay loam	CH or CL	A–7
		30–60	Silty clay loam	CL or ML	A–7 or A–6
Silty alluvial land: Sy	5–15	0–60	Silt loam and silty clay loam.	ML or CL	A–4 or A–6
*Slickspots: SZ. For Wabash part, see Wabash series.	6–15	0–60	Silty clay	CH	A–7
Sogn. Mapped only with Kipson soils.	>20	0–8	Silty clay loam	CL	A–7
		8–30	Limestone interbedded with silty clay loam and clayey shale.		
Wabash: Wa, Ws	6–15	0–60	Silty clay	CH or MH	A–7
Wet alluvial land: Wx. No valid estimates can be made.	1–5				
Wymore: Wt, WtA, WtC, WtC2, WtD2, WtD3	>20	0–14	Silty clay loam	CL or ML	A–7
		14–40	Silty clay	CH	A–7
		40–60	Silty clay loam	CL	A–7
Zook: Zo	6–15	0–25	Silty clay loam	CL or CH	A–7
		25–60	Silty clay	CH	A–7

[1] If two or more classifications are given and separated by "or," the first classification listed is considered to be the most common.

[2] The figures for available water capacity are averages based on water retention difference, as determined by laboratory test. Studies are continuing.

[3] From 0 to 10 percent limestone fragments ⅜ inch to 3 inches in diameter, and from 0 to 20 percent limestone fragments over 3 inches in diameter.

of significance in engineering—Continued

Percentage of material less than 3 inches passing sieve—				Material finer than 0.002 mm.	Permeability	Available water capacity [2]	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)					
				Pct.	*In./hr.*	*In./in. of soil*	*pH*	
------	------	100	95–100	15–28	0. 63–2. 00	0. 22–0. 24	6. 6–7. 3	Low to moderate.
------	------	100	90–100	15–30	0. 63–2. 00	0. 20–0. 22	6. 6–7. 3	Low to moderate.
------	------	100	95–100	35–50	0. 06–0. 20	0. 12–0. 14	7. 4–7. 8	High.
------	------	100	95–100	30–45	0. 06–0. 20	0. 12–0. 14	7. 4–7. 8	Moderate to high.
------	100	90–100	80–95	20–40	0. 20–2. 00	0. 20–0. 22	7. 9–8. 4	Moderate.
[4] 95–100	90–100	95–100	80–95	25–35	0. 20–0. 63	0. 17–0. 19	6. 1–6. 5	High.
[4] 95–100	90–100	85–95	75–85	35–45	0. 06–0. 20	0. 09–0. 11	6. 6–7. 3	High.
[4] 95–100	90–100	85–95	65–85	30–40	0. 06–0. 20	0. 12–0. 14	7. 4–7. 8	High.
------	100	95–100	13–40	2–7	6. 30–20. 0	0. 08–0. 10	7. 4–7. 8	Low.
------	------	100	95–100	25–35	0. 20–0. 63	0. 21–0. 23	5. 6–6. 0	Moderate to high.
------	------	100	95–100	28–35	0. 20–0. 63	0. 18–0. 20	5. 6–6. 0	High to moderate.
------	------	100	95–100	25–35	0. 20–0. 63	0. 18–0. 20	6. 1–6. 5	Moderate to high.
------	------	100	95–100	15–35	0. 20–2. 00	0. 19–0. 21	6. 1–7. 3	Moderate.
------	------	100	95–100	40–60	<0. 06	0. 06–0. 10	8. 5–9. 5	High.
[5] 70–85	75–85	75–85	70–80	30–45	0. 63–2. 00	0. 21–0. 23	7. 4–7. 8	Moderate to none for bedrock.
------	------	100	95–100	40–60	0. 06–0. 20	0. 10–0. 14	5. 6–7. 3	High.
------	------	100	95–100	35–45	0. 20–0. 63	0. 21–0. 23	5. 6–6. 0	Moderate to high.
------	------	100	95–100	40–55	0. 06–0. 20	0. 11–0. 13	6. 1–6. 5	High.
------	100	95–100	95–100	20–30	0. 20–0. 63	0. 18–0. 20	6. 6–7. 3	Moderate to high.
------	100	95–100	95–100	30–40	0. 20–0. 63	0. 19–0. 23	6. 1–6. 5	Moderate to high.
------	100	95–100	95–100	35–45	0. 06–0. 20	0. 11–0. 13	6. 6–7. 3	High.

[4] From 0 to 5 percent gravel ⅜ inch to 3 inches in diameter.

[5] From 5 to 10 percent limestone fragments ⅜ inch to 3 inches in diameter, and from 10 to 20 percent limestone fragments over 3 inches in diameter.

TABLE 6.—*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 tions for referring to other series that

Soil series and map symbols	Suitability as source of—			Soil features affecting—		
	Topsoil	Subgrade of paved roads	Road fill	Highway location	Foundations	Dikes and levees
Albaton: Ak	Poor: poorly drained; silty clay texture.	Poor	Poor: high clay content; poorly drained.	High susceptibility to frost action; erodibility of slopes; occasional flooding; requires 4 to 7 feet of fill; ponding.	High shrink-swell potential; subject to flooding.	Erodibility; cracks when dry.
*Benfield: BfB2, BKB3. For Kipson part of BKB3, see Kipson series.	Fair: thin silty clay loam surface layer.	Poor	Fair to poor: weathered shale; requires special consideration.	High susceptibility to frost action; bedrock at a depth of 40 inches.	Bedrock at a depth of 40 inches.	(1)
Geary: GeC2, GeC3	Fair to poor: slopes; thin light silty clay loam surface layer.	Poor	Fair to poor: moderate to high shrink-swell potential.	High susceptibility to frost action; erodibility of slopes.	Moderate to high shrink-swell potential; slopes.	(1)
Gullied land: GL. Variable. Onsite determination is necessary.						
*Haynie: HA, He, HS. For Albaton part of HA, see Albaton series. For Sarpy part of HS, see Sarpy series.	Fair: moderately thick surface layer.	Fair to poor	Fair to poor: erodibility of slopes; requires close control of borrow and fills.	Erodibility of slopes; high susceptibility to frost action; seasonal high water table; in places requires minimum fills; subject to flooding.	Poor to fair bearing capacity, depending on density and moisture level; possible seepage.	Erodibility of slopes; in places subject to seepage.
Hobbs: Hv	Good	Fair to poor	Fair if compaction control is adequate.	Erodibility of slopes; high susceptibility to frost action; subject to occasional flooding in places; requires mimimum fills.	Fair bearing capacity, depending on density; subject to flooding.	Erodibility of slopes.

See footnote at end of table.

interpretations

in such mapping units may have different properties and limitations and for this reason it is necessary to follow carefully the instruc-
appear in the first column of this table]

Soil features affecting—Continued					Degree and kind of soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Filter fields	Sewage lagoons
Reservoir area	Embankment					
Low seepage; in places is suitable for excavated ponds.	Fair to poor stability; impervious; poor workability.	Poor drainage; subject to occasional flooding; slow permeability; slow runoff; ponding; in places suitable outlets not available.	(1)	(1)	Severe: slow permeability; subject to flooding.	Severe: requires protection from flooding.
Moderate to low seepage; bedrock at a depth of 40 inches.	Fair stability; fair to poor workability; impervious; shallow borrow areas.	Good drainage; slow permeability; medium to rapid surface runoff.	Erodibility of slopes.	Erodibility; bedrock at a depth of 40 inches.	Severe: slow permeability; slopes; bedrock at a depth of 40 inches.	Moderate: slopes; bedrock at a depth of 40 inches; cracks when dry.
Low seepage	Good stability; fair to good workability; slow permeability when compacted.	Good drainage; moderately slow permeability; medium to rapid runoff.	Erodibility of slopes.	Erodibility; lower fertility in cuts.	Severe: moderately slow permeability.	Moderate: slopes; compacted soil required for linings.
Moderate seepage.	Fair stability; erodibility; in places subject to seepage; requires adequate compaction control; fair workability.	Moderately good drainage; moderate permeability; slow surface runoff; subject to occasional flooding.	(1)	(1)	Severe: subject to flooding; moderate permeability.	Severe: moderate permeability; requires sealing or lining; subject to flooding.
Moderate seepage; in places used for excavated ponds.	Fair stability; erodibility of slopes; in places is subject to seepage; requires close control; fair to good workability.	Moderately good drainage; moderate permeability; slow surface runoff; subject to occasional flooding.	(1)	(1)	Severe: subject to flooding; moderate permeability.	Severe: moderate permeability; subject to flooding.

TABLE 6.—*Engineering*

Soil series and map symbols	Suitability as source of—			Soil features affecting—		
	Topsoil	Subgrade of paved roads	Road fill	Highway location	Foundations	Dikes and levees
Ida: IdD2, IdF2	Fair to poor: slopes; thin surface layer.	Poor	Fair if compaction control is adequate; erodibility of slopes.	Erodibility of slopes; in places steep topography requires high cuts and fills; high susceptibility to frost action.	Slopes	(1)
Judson: JuA	Good	Poor	Fair: requires adequate compaction control; moderate shrink-swell potential.	Moderate to high susceptibility to frost action; erodibility of slopes.	Moderate shrink-swell potential; susceptibility to frost action.	Erodibility of slopes.
Kennebec: Ke	Good	Fair to poor	Fair in surface; poor in deeper layers; erodibility of slopes; moderate shrink-swell potential.	Moderate to high susceptibility to frost action; slopes.	Moderate shrink-swell potential; susceptibility to frost action; possible seepage.	Erodibility of slopes; in places is subject to seepage in surface layer.
*Kipson: KBD, KSD For Benfield part of KBD, see Benfield series. For Sogn part of KSD, see Sogn series.	Fair: shallow; moderately sloping.	Poor	Fair to poor: shallow borrow areas; shale requires special consideration.	High susceptibility to frost action; erodibility of slopes; depth to bedrock ranges from 7 to 20 inches.	Excavations in clayey shale at shallow depths.	(1)
Marshall: MaA, MaB, MaC2, MaC3.	Fair workability; moderately thick surface layer.	Poor	Fair: requires close compaction control; moderate to high shrink-swell potential.	Erodibility of slopes; high to moderate susceptibility to frost action; in places steeper slopes require high cuts and fills.	Moderate to high shrink-swell potential; susceptibility to frost action; possible seepage.	(1)
Mayberry Mapped only with Pawnee soils.	Fair: high clay content in surface layer.	Poor	Fair to poor: requires close compaction control and control of frost action; moderate to high shrink-swell potential.	Moderate to high susceptibility to frost action; moderate to high shrink-swell potential; erodibility of cut slopes.	Moderate to high susceptibility to frost action; moderate to high shrink-swell potential; in places affect shallow foundations; slow permeability.	(1)

See footnote at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Filter fields	Sewage lagoons
Reservoir area	Embankment					
Moderate seepage.	Fair stability; fair to good workability; requires close compaction control.	Good drainage; moderate permeability.	Erodibility; irregular topography.	Erodibility	Severe: slopes	Severe: slopes; moderate permeability.
Low to moderate seepage.	Fair to good stability; impervious; fair to good workability.	Good drainage; moderate to moderately slow permeability; slow to medium surface runoff.	Moderate erodibility.	Moderate erodibility.	Moderate: moderate permeability.	Moderate: moderately slow permeability.
Moderate seepage.	Fair stability; impervious; good to fair workability; moderate compressibility; requires close compaction control.	Good drainage; moderate to moderately slow permeability; slow surface runoff.	(1)	(1)	Moderate: moderate permeability.	Severe: subject to flooding; moderate permeability.
Moderate to moderately low seepage; limited depth because of shallow bedrock.	Good to poor stability; fair to poor workability; rock fragments; limited borrow; shale requires special consideration.	Somewhat excessive drainage; moderate permeability to bedrock; slow permeability in substratum; rapid surface runoff.	Features generally favorable; erodibility; irregular slopes; shallow.	(1)	Severe: bedrock at a shallow depth.	Moderate to severe: shale bedrock at a shallow depth; moderate to slow permeability.
Low seepage	Good stability; impervious; fair workability; moderate compressibility; requires compaction control.	Good drainage; moderately slow permeability; medium to rapid surface runoff.	Erodibility; irregular topography.	Erodibility; steep slopes.	Severe: moderately slow permeability.	Moderate: requires compacted soil for sealing; slopes.
Low seepage	Fair stability if compaction is controlled; fair workability; medium compressibility; impervious.	Moderately good drainage; slow permeability; medium to rapid surface runoff.	Erodibility of slopes and cuts; lower fertility in cuts.	Erodibility of slopes; medium fertility.	Severe: slow permeability.	Moderate: in places permeability moderate in excavations; in places requires clay layers for compacted liner; moderate slopes.

TABLE 6.—*Engineering*

Soil series and map symbols	Suitability as source of—			Soil features affecting—		
	Topsoil	Subgrade of paved roads	Road fill	Highway location	Foundations	Dikes and levees
Monona: MnB, MnC, MnC2, MnD, MnD2, MnF.	Poor to good: slopes; moderately thick surface layer.	Poor	Fair: requires close compaction control and control of frost action under pavement.	Erodibility of slopes; high susceptibility to frost action; in places steeper topography requires high cuts and fills.	Susceptibility to frost action; in places trenches unstable.	(1)
Morrill: MC2, MC3, MD.	Fair to poor: slopes; clay content in deeper layers.	Fair to poor	Good to poor if compaction and borrow control are adequate; requires control of frost action under pavement; moderate to high shrink-swell potential.	Erodibility of slopes; high to moderate susceptibility to frost action.	Sandy soils in places; seepage; moderate to high shrink-swell potential.	(1)
Nodaway: Nd	Fair: moderately thick surface layer.	Poor to fair	Fair if compaction control is adequate.	Erodibility of slopes; high susceptibility to frost action.	Bearing capacity depends on density and moisture; susceptibility to frost action.	Erodibility of slopes; in places subject to seepage.
Onawa: Oc	Poor: high clay content; moderately thick surface layer.	Poor to fair	Fair to poor: high clay content in upper 1½ feet.	Moderate to high susceptibility to frost action; seasonal high water table; in places ponding and occasional flooding require 4 to 7 foot fills; erodibility of slopes.	Bearing capacity depends on density and moisture; seepage; susceptibility to frost action.	Erodibility of slopes; in places cracks when dry; subject to horizontal seepage.
*Pawnee: PAC2, PAD2, PAD3. For Mayberry part, see Mayberry series.	Fair to poor: high clay content.	Poor	Poor: high clay content; requires consideration of compaction and susceptibility to frost action.	High susceptibility to frost action; slopes; variable topography.	Susceptibility to frost action; high shrink-swell potential; needs local determination for site.	(1)
Rough broken land: RB. Variable. Onsite determination is necessary.						

See footnote at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Filter fields	Sewage lagoons
Reservoir area	Embankment					
Low to moderate seepage.	Fair to good stability; impervious; erodibility of slopes; fair to good workability; requires compaction control.	Good drainage; moderate permeability; medium to rapid surface runoff.	Erodibility of slopes; irregular topography.	Erodibility; steep slopes in places.	Severe where slopes are steep; moderate for other slopes; moderate permeability.	Severe: moderate permeability; slopes.
Requires check for sand or rock areas in glacial till.	Good stability; low compressibility; good to fair shear strength; requires control of borrow areas.	Good drainage; moderately slow to moderate permeability; medium to rapid surface runoff.	Erodibility of slopes; in places cuts expose sandy soil.	Erodibility; in places cuts expose sandy materials.	Moderate: moderately slow to moderate permeability; slopes; possible sandy soils that have moderately rapid to rapid permeability.	Severe: moderately slow to moderate permeability; slopes; requires clayey soils for compacted liner.
Moderate seepage.	Fair stability; in places drainage required; fair to good workability.	Good drainage; moderate permeability; slow surface runoff.	(1)	(1)	Moderate: moderate permeability.	Severe: moderate permeability; requires sealing or lining.
Moderate to low seepage; in places used for excavated ponds.	Erodibility of slopes; fair stability; fair workability; requires control of borrow and compaction.	Somewhat poor drainage; subject to occasional flooding; slow permeability in the upper part; moderate permeability in the lower part; slow surface runoff; subject to ponding; suitable outlets may not be available.	(1)	(1)	Severe: moderate permeability; subject to flooding.	Severe: subject to flooding; slow to moderate permeability.
Low seepage	Erodibility of slopes; good stability; fair workability; moderate compressibility; impervious.	Moderately good drainage; slow permeability; medium to rapid surface runoff.	Erodibility of slopes.	Erodibility; low fertility.	Severe: slow permeability; gentle and moderate slopes.	Moderate to severe.

TABLE 6.—*Engineering*

Soil series and map symbols	Suitability as source of—			Soil features affecting—		
	Topsoil	Subgrade of paved roads	Road fill	Highway location	Foundations	Dikes and levees
Sarpy: Sg	Poor: susceptible to soil blowing; low fertility.	Fair to poor	Good	Low susceptibility to frost action; erodibility; subject to occasional flooding; in places requires minimum fills.	Good bearing capacity if sand is confined; trenches unstable.	Erodibility of slopes; subject to horizontal seepage.
Sharpsburg: ShA, ShB2, ShC2, ShC3.	Fair: silty clay loam texture; slopes; moderately thick surface layer.	Poor	Fair to poor: high clay content; moderate to high shrink-swell potential.	High susceptibility to frost action: erodibility of slopes.	Bearing capacity depends on density and moisture; moderate to high shrink-swell potential.	Erodibility of slopes.
Silty alluvial land: Sy	Fair to good	Fair to poor	Fair to poor: erodibility of slopes; variable in borrow areas.	Moderate to high susceptibility to frost action; erodibility of slopes; high water table and frequent flooding require 4 to 7 feet fills.	Bearing capacity needs to be determined on site; subject to flooding and seepage.	Erodibility of slopes; in places subject to seepage.
*Slickspots: SZ For the Wabash part, see Wabash series. Variable. Onsite determination is necessary.	Poor: moderately alkaline to strongly alkaline.	Poor	Poor: high shrink-swell potential; susceptible to frost action; water table.	Moderate susceptibility to frost action; in places ponding and slow drainage require minimum fills.	High shrink-swell potential; susceptibility to frost action; subject to ponding.	Erodibility of slopes; in places cracks when dry.
Sogn Mapped only in complex with Kipson soils.	Poor: shallow over bedrock; slopes.	Fair to good	Poor for surface soil; good for rock fill if required.	Surface soil poor for borrow; excavations require special consideration for method and use of materials; paved or gravel surface requires special design.	Excavations in bedrock.	([1])

See footnote at end of table.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Filter fields	Sewage lagoons
Reservoir area	Embankment					
High seepage; dugouts possible.	Fair stability; erodibility of slopes; subject to seepage; good workability; requires compaction control.	Excessive drainage; rapid permeability; slow surface runoff.	(1)	(1)	Moderate: subject to occasional flooding; trenches unstable.	Severe: rapid permeability.
Moderately slow seepage.	Fair stability; impervious; fair workability; erodibility of slopes; moderate compressibility; requires compaction control.	Moderately good drainage; moderately slow permeability; medium to rapid surface runoff.	Erodibility; irregular topography.	Erodibility	Severe: moderately slow permeability.	Slight to severe: slopes; requires compaction for sealing.
Moderate seepage; in places used for excavated ponds.	Fair stability; fair workability; erodibility of slopes; in places drainage required.	Moderately good drainage; subject to frequent flooding.	(1)	(1)	Severe: subject to flooding.	Severe: subject to flooding.
Low seepage	Poor stability; erodibility of slopes; poor workability; high compressibility; plastic.	Poor drainage; very slow permeability; slow runoff; subject to ponding.	(1)	(1)	Severe: very slow permeability.	Moderate: shrink-swell potential.
(1)	Fair to poor stability; poor workability; rock fragments; limited borrow.	Somewhat excessive drainage; moderate permeability; medium to rapid surface runoff.	(1)	(1)	Severe: bedrock at a depth of 1 foot.	Severe: bedrock at a depth of 1 foot.

TABLE 6.—*Engineering*

Soil series and map symbols	Suitability as source of—			Soil features affecting—		
	Topsoil	Subgrade of paved roads	Road fill	Highway location	Foundations	Dikes and levees
Wabash: Wa, Ws	Poor: high clay content.	Poor	Poor: high clay content; poorly drained; high shrink-swell potential.	In places ponding and slow drainage require 4 to 7 feet of fill: subject to flooding; susceptibility to frost action depends on density and available water.	High shrink-swell potential; moisture.	Erodibility of slopes; cracks when dry; poor workability.
Wet alluvial land: Wx. Variable. Onsite determination is necessary.						
Wymore: Wt, WtA, WtC, WtC2, WtD2, WtD3.	Fair: high clay content; slopes.	Poor	Poor to fair if compaction and borrow area are controlled; moderate to high shrink-swell potential.	Susceptibility to frost action and shrink swell, depending on density; erodibility of slopes.	Bearing capacity depends on density and moisture check at site; moderate to high shrink-swell potential; susceptibility to frost action.	Erodibility of slopes; cracks when dry.
Zook: Zo	Poor to fair: high clay content.	Poor	Poor: difficult to transport and compact; moderate to high shrink-swell potential.	Susceptibility to frost action; moderate to high shrink-swell potential depending on density and moisture; in places surface ponding requires 4 to 7 foot fills.	Conditions variable for bearing; trenches unstable in places; seepage and wet sites in places; moderate to high shrink-swell potential.	Erodibility of slopes; cracks when dry.

[1] Generally not applicable because of position, slope, or other soil features.

interpretations—Continued

Soil features affecting—Continued					Degree and kind of soil limitations for sewage disposal	
Farm ponds		Agricultural drainage	Terraces and diversions	Grassed waterways	Filter fields	Sewage lagoons
Reservoir area	Embankment					
Low seepage; in places used for excavated ponds.	Fair to poor stability; fair to poor workability; erodibility of slopes; high compressibility; compaction control difficult.	Poor drainage; slow permeability; slow surface runoff; some ponding; in places suitable outlets not available.	(1)	(1)	Severe: slow permeability.	Moderate: requires protection from flooding; moderate for excavation and dike construction.
Low seepage	Good stability; impervious; fair workability; moderate compressibility; requires compaction control.	Moderately good drainage; slow permeability; slow to rapid surface runoff.	Erodibility; nearly level to strongly sloping.	Erodibility	Severe: slow permeability; slopes.	Moderate to severe: slopes.
Low seepage; in places used for excavated ponds.	Fair stability; fair workability; impervious; moderate compressibility requires close compaction control.	Somewhat poor drainage; slow permeability; slow surface runoff; in places suitable outlets not available.	(1)	(1)	Severe: slow permeability.	Moderate: requires check for water table and protection from flooding.

The mechanical analysis was made by a combination of the sieve and hydrometer methods. The engineering classifications in the last two columns of table 4 are based on data obtained by mechanical analysis and on tests to determine the liquid limit and plastic limit.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 6, but in table 4 the data on liquid limit and plasticity index are based on tests of soil samples.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 5. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for 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 5.

Soil texture is described in table 5 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey. The AASHO and Unified engineering classifications are also given in this table.

The estimates in table 5 were based on the engineering test data in table 4 and on other information obtained in the county during the survey. The data are listed by strata that have properties significant to engineering. These data include the textural classification of the United States Department of Agriculture and the AASHO and Unified engineering classifications. Also listed for each layer are the percentages of material that will pass a No. 4 sieve, a No. 10 sieve, a No. 40 sieve, and a No. 200 sieve, and the percent finer than 0.002 mm. as determined by the hydrometer method. Estimates of the percentage passing the sieves are based on the assumption that material up to and including 3 inches in diameter equals 100 percent. Except for the Sogn and some of the Kipson soils, Richardson County does not have soils with a significant percentage of coarse materials greater than 3 inches.

In the AASHO and Unified systems, soil r ticles retained on the number 200 sieve are classified as sand and gravel. Silt and clay particles pass through this sieve. The range of values shown in table 5 for the percent of soil finer than 0.002 mm. represents the estimated clay fraction of the soil. Silt and clay particles can affect such properties as strength, permeability, compaction, and shrink-swell potential.

In tables 4 and 5 the clay percentage is based on an analysis which uses the hydrometer method (AASHO Designation T–88). This can give results that differ slightly from those obtained with the pipette method used by SCS soil scientists to obtain results with standard soil survey procedures.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 5 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

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

Reaction of a soil is the degree of acidity or alkalinity, expressed as a pH value or reaction class. A pH value of 7.0 is absolute neutral; one with a lower value is acid, and a soil with a pH greater than 7.0 is alkaline. In Richardson County, soils have pH values ranging from 5.6 to 8.4 and onsite investigation is needed to determine the potential corrosive hazard to metal structures. The reaction classes for most horizons of the representative profile are given in the section "Descriptions of the Soils." Tests for corrosive potential need to be made on moist or wet soils used as construction materials.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

A generalized rating for shrink-swell potential is given in table 5. Several soils, such as those in the Albaton, Pawnee, and Wabash series, have moderate to high shrink-swell potential. Generally, soils with a high content of expandable clay, such as montmorillonite, undergo a volume change when the soil moisture level is changed. Clean sands and gravels undergo little or no volume change when wetting or drying occurs.

Soil dispersion is not a serious problem because few areas contain enough salts to produce moderate dispersion. Salinity generally is not a problem. However, in the poorly drained bottom land soils, some areas are saline. The Slickspots-Wabash complex is an example. Onsite investigation is needed in all areas where salinity poses a hazard to construction work.

The depth to bedrock is more than 5 feet in all soils of the county except Benfield, Kipson, and Sogn soils.

Benfield soils are 20 to 40 inches deep over shale. Kipson soils are only 7 to 20 inches deep over shale. Sogn soils are only 5 to 20 inches deep over limestone.

Engineering interpretations of soils

Table 6 indicates a general interpretation of the soils for their use in engineering. This table is a guide to planning and further investigation of the soils. Onsite investigation of the soils for type, quantities, and engineering properties is important.

In table 6, topsoil is rated *good*, *fair*, or *poor*, depending on fertility, organic-matter content, erodibility, and workability. Topsoil is used to cover road and dam embankments, on excavated slopes, and on gardens and lawns.

Two soils in Richardson County are minor sources of sand and gravel. The Morrill soils contain pockets of sand and gravel. Sarpy soils contain 60 percent, or less, sand with no gravel sizes. Exploration is needed to determine quantity and gradation. Operational sandpits are a guide to locating sources of sand and gravel.

Ratings for use of soil as road fill include suitability as embankment, as a foundation for embankments, erodibility of cut slopes, and potential frost action. Sands and gravels are rated *good* to *fair* for subgrades under pavement and *poor* for gravel road subgrades. Silt and clay on the road subgrade surface are more stable for gravel surfacing. Thus, for paved roads, AASHO class soils A–1 and A–3 are rated *good*; A–2, *good* to *fair*; A–4, *fair* to *poor*; and A–6 or A–7, *poor*. For most soils the road subgrade (foundation) and road fill use the same classification for paved roads because the engineering requirements are approximately the same.

Highway locations are described according to potential problems of frost heave, shrink swell, erodibility of cut and fill slopes, and depth to the water table, and they are rated as *good*, *fair*, or *poor* for road subgrade. Frost action is caused by the expansion of freezing water in silt-clay soils which, in turn, increases maintenance of paved roads. A high water table can contribute to potential frost action or frost heave.

Foundations are rated generally on bearing or load-carrying capacity. Most soils have a high bearing capacity when dry. Some of the windblown soils are subject to high consolidation when saturated under load. Sands and gravels (see AASHO classifications) have high bearing capacity when confined. Specific values for bearing capacity (for example, pounds per square inch) should not be assigned to estimated values as expressed in words in table 6. Wet excavations for buildings may be a problem. Therefore, depth to water should be determined for building sites. The potential for shrink swell from table 5 is important also to foundations.

Dikes and levees are used to control surface water. They are subject to water erosion, soil blowing, and horizontal seepage if not properly compacted or if constructed of clean sands. Some soils are subject to shrinkage and cracking upon drying. Dikes and levees constructed with sandy soils need flat slopes for stability. Steeper slopes are used for dikes and levees constructed with clay soil, because the fill is relatively impervious to water.

For farm ponds, potential seepage in the soil and the use of soil for reservoir areas and embankments are described in table 6. A high water table indicates the possibility of excavating a dugout for a water supply. A low, or deep, water table may indicate the need for sealing or lining a reservoir; it also indicates that construction of a fill may be easier, because the foundation is drier.

Embankments are subject to seepage and compressibility. These factors are rated in table 6. Workability includes hauling and compaction characteristics. Potential seepage depends on moisture, gradation, and compaction of the fill. See table 4 for test results giving maximum dry density and optimum moisture for the particular samples. Erodibility of fill slopes is also described.

Agricultural drainage, as described in table 6, depends on the depth to the water table, available outlets, and permeability of the various soil layers.

Use of the soils for terraces, diversions, and grassed waterways is described according to possible water erosion and soil blowing, difficulty of establishing vegetation, and soil fertility. Maintenance costs of terraces and diversions are greater where siltation occurs from higher elevations. Depth to erodible sands will limit cut depths for diversion alinement. Rough topography and steep slopes are factors in terrace and diversion alinement.

For sewage disposal, the limitations for use of sewage filter fields and sewage lagoons according to the soil are given in table 6. Use of soils for sewage disposal can also be related to table 6, including values for soils classification, permeability, and available water capacity. For filter fields, soil limitations are *slight*, *moderate*, or *severe*. *Slight* includes good infiltration without contaminating the underground water; *moderate* includes a finer grained soil with a lower intake rate; *severe* includes a high water table or an impervious soil.

For sewage lagoons, water must be retained in the lagoon for aerobic decomposition of the fresh sewage to occur. Thus, an impervious soil is desired for constructing this facility. The probability of a soil requiring sealing with bentonite or sodium carbonate or lining with a commercial plastic or rubber liner is indicated. For some soils, mixing and compacting the inplace soil will provide a relatively impervious liner. A lagoon constructed in sandy material that has a high water table (*severe*) would be the least desirable sewage disposal facility. Proper location of a sewage filter field or disposal lagoon insures that wells that furnish domestic water supply or stock water are not contaminated. Steepness of slope, the possibility of flooding, and other factors are considerations in sewage treatment design.

Suitability of soils for irrigation is affected by available water capacity, permeability, surface intake rate, steepness of slopes, possible limiting depths of leveling cuts, and other factors. Further information on soil use for irrigation is contained in *Irrigation Guide for Nebraska*.[8] The ratings for available water capacity are limited to the top 5 feet of soil. The rating is *high* if the soil holds more than 9 inches of water; *moderate* if the soil holds 6 to 9 inches; *low* if the soil holds 3 to 6 inches; and *very low* if the soil holds less than 3 inches.

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[8] 1971. IRRIGATION GUIDE FOR NEBRASKA, Soil Conservation Service

Formation and Classification of the Soils

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

Factors of Soil Formation

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

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and in extreme cases determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Generally, a long time is required for the development of distinct horizons.

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

Parent material

Parent material of soils consists of geologic deposits exposed to soil formation. The soils in Richardson County formed in several kinds of parent material that differ in physical characteristics and in geologic age. Alluvium is the youngest material, and limestone and shale, deposited in an ancient sea, are the oldest. The importance of these materials in relation to soils is not the age relationship but the effects of their mineral composition and physical properties on soil formation.

Soils inherit certain characteristics from the parent material. The pebbles, stones, and boulders of a glacial soil and the limestone fragments of a soil that formed in limestone are characteristics that are not easily lost or changed. Generally, a soil that has pebbles and grit formed in a parent material that was pebbly or gritty, and a soil lacking pebbles and grit formed in a material free of coarse deposits. Sometimes a soil forms in more than one kind of parent material, especially where deposits of parent material are thin or mixed. More often, however, several soils form in the same kind of parent material but differ from each other in the thickness, color, clay content, and number and arrangement of soil horizons. Different soils that form in the same parent material have characteristics which generally reflect the controlling soil-forming factors, climate and relief.

In the soils in Richardson County, there is no great difference in the time that soil formation has been active. Geologic erosion stripped most of the ancient soils from the landscape and exposed fresh soil parent material. Therefore, the soils forming in material that is a million years old have been forming for about the same length of time as the soils forming in the more recent material less than 20,000 years old.

Parent materials in Richardson County, in the order of their geologic age or deposition, are (1) interbedded limestone and shale, (2) till left by glaciers, (3) gravelly to clayey sediment reworked from till, (4) Loveland Loess, (5) Peoria Loess, and (6) alluvium.

Interbedded limestone and shale are sources of parent material on valley slopes in the dissected area of southwestern Richardson County. In these areas, geologic erosion has completely removed the younger deposits that generally cover this bedrock material. The bedrock consists of relatively thin layers of limestone that alternate with layers of shale. The limestone ranges from hard to soft. In a few places, remnants of very hard and brittle cherty beds are present, indicating that at one time a period of weathering had completely leached out the calcium carbonate from the lime rock. In some places, soft sandstone that contains mica appears within layers of the limestone. The shale beds contain lime, the structure of the shale is coarsely laminated or platy, and the colors range from olive to red. Some of the shale contains large amounts of clay, and in places, it has considerable amounts of mica. Kipson, Benfield, and Sogn soils formed in this parent material.

Till of the Kansan age, left by glaciers, contributes to some soils on the valley slopes in western Richardson County. Where it has not been completely removed by geologic erosion, it overlies the bedrock of limestone and shale. The till is generally grayish in color when unoxidized, but when it is exposed and weathered, it is of a yellowish or brownish color. It is a fine earth mixture of silt, sand, and clay; it is studded with pebbles; and occasionally it contains stones or quartzite boulders. Relatively thin layers or isolated pockets of sand and gravel occur within the till section. The Pawnee soils formed in till.

Gravelly and clayey material reworked from till contributes to some soils on dissected valley slopes in the western part of the county. This type of parent material is exposed throughout the areas associated with the till of the Kansan glacier. Its striking feature is its reddish to brownish color. Textures range from sand and gravel to clay, and in places the material is stratified. The Morrill and Mayberry soils formed in this kind of material.

Loveland Loess occurs above the till but underlies the Peoria Loess. It is relatively thin but the most striking feature is the reddish color that formed during a period of weathering and soil formation. It is uniformly silty clay loam in texture, but in places it contains some very fine sand. The Geary soils formed in Loveland Loess.

Peoria Loess, a stone-free, fine silty material, was swept up and carried to its present location by the wind. It mantles the nearly level divides, gently sloping ridgetops, and high upland slopes. It also occurs on the benchlike positions and foot slopes. Generally, Peoria Loess rests unconformably on the Loveland Loess, glacial deposits, or bedrock in Richardson County. Thick, yellowish to brownish deposits occur in the eastern part of the county bordering the Missouri River Valley. Relatively thick grayish to brownish deposits occur in the western part of the county. Many of the valley slopes in the western part have been stripped of this loess by geologic erosion. Peoria Loess is uniform in texture, has an abundance of weatherable minerals, and generally forms soil rapidly. It is the most extensive of the soil parent materials in the county, and several soils formed in it, including the Ida, Monona, Marshall, Sharpsburg, and Wymore soils.

Alluvium is a source of parent material to many kinds of soils and to a large acreage of soils on the bottom land in Richardson County. Alluvium is a heterogeneous mixture of silt, clay, and sand washed from upland areas, carried by flow water, and deposited by rivers and streams. It covers the bottom land and foot slopes in Richardson County in various thicknesses. In some places, it is still being deposited, although some alluvium has been in place for some time. Soils formed in alluvium differ according to their source, whether sandy, silty, or clayey. The soils also differ in drainage characteristics. Alluvium is the parent material of the Albaton, Haynie, Hobbs, Judson, Kennebec, Nodaway, Onawa, Sarpy, Wabash, and Zook soils. Alluvium is also the material for the land types Wet alluvial land and Silty alluvial land.

Climate

Climate is important in the formation of soils. During the last main geologic period, there were many climatic cycles. This influenced the shaping of the landscape and deposition of parent materials in Richardson County. Long periods of moisture and cold temperatures activated glaciers which left glacial material. Dry and windy periods produced dust which accumulated as loess deposits. Stable periods of weathering and soil formation were interspaced with periods of dissection and erosion.

Since land shaping and deposition, parent material has undergone marked changes in color, structure, and composition. These changes are caused mainly by leaching, oxidation, and other weathering processes; by the accumulation of organic matter; by the concentration of colloids or clay in the subsoil; and by the partial removal of lime from the surface layer and the upper part of the subsoil. The climate is believed to have been of great influence in fixing the present character of the soils in Richardson County. One feature is the uniform chemical composition of soils on similar relief but of different parent materials. Parent material varied widely in composition, particularly in the content of free calcium carbonate, but leaching has largely removed these carbonates as well as other soluble constituents to a depth below the subsoil. Except for areas of steep slopes and recent alluvium, most of the soils in Richardson County have a surface layer and upper subsoil that are slightly acid. Although the soils in the county are somewhat leached but not highly leached, they retain a high percentage of basic elements, which is one of many requirements for a fertile soil.

Within an area as small as Richardson County, the climate is fairly uniform, and local differences in soils cannot be attributed to differences in climate. Climate causes differences in soils over broad regions. For example, in an area where the year-round climate is warm and humid, the soils are more leached, more acid, and contain less organic matter than soils in Richardson County. Major differences in soils reflect climatic conditions in other broad climatic belts.

Climate affects weathering and soil formation by the kind and amount of rainfall, the temperature, the humidity, and nature of winds. The effects of climate are modified by the nature of the parent material and the relief. Climate, in turn, affects soil formation through its influence on the type and variety of plant and animal life.

Plant and animal life

Plant and animal life has a pronounced effect on soil formation in Richardson County. The vegetation, determined by climate on a particular site, is one of the most important factors. Animals are important in the way they use and convert this vegetation to organic matter.

One of the broadest and most striking characteristics of the soils is the dark color imparted by rather large amounts of organic matter. Bluestem prairies dominated the landscape. The stems, leaves, and roots of the tall grasses produced the organic material. As a result, a number of soils have a dark-colored surface layer. In addition, the plants extract calcium and other minerals from the lower part of the soil and return them to the surface through their stems and leaves. This process tends to renew the upper part of the soil with basic elements. Normally, dark colors caused by the distribution and subsequent decay of fibrous roots extend gradually into the subsoil.

Soils on nearly level and gently sloping positions generally have a thicker and somewhat darker surface layer than soils on steeper slopes, because they had more moisture and a better growth of vegetation, and they have lost less soil by erosion. Some bottom-land soils are thick and dark, because the parent alluvium was dark colored.

Micro-organisms, ants, earthworms, and burrowing rodents have a beneficial effect on soil structure, permeability, aeration, and fertility. Many kinds of microorganisms convert organic remains into stable humus from which plants obtain nutrients. Earthworms and small burrowing animals influence the formation of soil by mixing the organic and mineral parts of the soil and by deepening the zone in which the organic matter accumulates. They also help to keep soils aerated and supplied with fresh minerals by bringing unleached parent material to the surface.

The activity of man affects the formation of soil. Some of the effects are accelerated sheet and gully erosion, changes in moisture content caused by runoff and improved drainage, and the addition of plant nutrients and other soil amendments. In places, man's activity has drastically changed the kinds of living organisms in the soil. Most of these changes affect soil development, but the effect of some changes may not be evident for centuries. Man can immediately change the soil by disturbing it, by adding chemicals, or by doing other things to make it suitable for his use.

Relief

Differences among soils can be attributed to local variations in relief. Relief affects soil formation mainly through its effects on drainage and runoff. In this way, relief modifies the climatic factor. Runoff is more rapid where slopes are steep than where they are more nearly level or gently sloping. Consequently, less water soaks into the soil and there is less leaching. In addition, there is greater movement of materials downslope through creep and erosion on steeper slopes. Soils on steep slopes generally have less distinct horizons and a thinner solum than soils in more nearly level or gently sloping areas.

Relief or position of soils is important in several other ways. A high water table and the addition of surface water by runoff or flooding increase the moisture content of soils, which affects the kind and amount of vegetation, weathering, and soil formation. Ridges and hillsides are more exposed to changes in soil temperature and to the drying effects of wind and sun than are lower lying areas. Nearly level soils that have slow permeability dry slowly and have poor aeration which causes gleying. Sloping soils that have a clay subsoil, slow permeability, and are bare of vegetation have rapid runoff.

Time

Differences in the time a soil has been affected by soil-forming processes are commonly reflected in the properties of the soil. Generally, soils have to be in place for some time to develop genetic profiles and thick horizons. If the parent material has been in place for only a short time, the climate and vegetation have not had long to act, and the soils are weakly developed. The Haynie, Hobbs, and Kennebec soils are good examples of weakly developed soils. These soils formed in recent alluvium deposited during the last few centuries, some during the last few years.

The Marshall, Sharpsburg, and Wymore soils formed in Peoria loess that has been in place long enough for well-defined, genetically related horizons to form. This is also true of the Pawnee soils, which formed in glacial till, and the Benfield soils, which formed in shale. Ida and Kipson soils, not leached of calcium carbonate, have been developing for a short time, because they occur on rather steep slopes, and soil material is removed about as fast as it forms. The longer the parent material is exposed to soil development, the more nearly the soil reaches a balance with its environment. Under grass, the surface layer can be darkened in 10 to 150 years in this climate. Several centuries are required to develop other genetically related horizons such as those in the Sharpsburg, Wymore, and Pawnee soils.

Classification of Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*5*). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (*3*) and adopted in 1965 (*7*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 7 shows the classification of each soil series of the county by family, subgroup, and order, according to the current system.

Data on mechanical and chemical analyses for the Mayberry (Adair), Marshall, Monona, Morrill, Pawnee, Sharpsburg, Wabash, and Wymore soils are published in Soil Survey Investigations Report No. 5 (*9*). This information is useful to soil scientists in classifying soils and in developing concepts of soil genesis. It is also useful in estimating available water capacity, fertility, tilth, and other properties of soils that concern management.

ORDER.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate between 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 7 shows that the two soil orders in Richardson County are Entisols and Mollisols.

Entisols are light-colored soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

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

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. The suborder is not shown in table 7.

GREAT GROUPS.—Each suborder is divided into great groups on 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 fragipan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 7, because it is the last word in the name of the subgroup.

TABLE 7.—*Soil series classified according to the current system of classification*

Soil series	Family [1]	Subgroup	Order
Albaton	Fine, montmorillonitic (calcareous), mesic	Vertic Fluvaquents	Entisols.
Benfield [2]	Fine, mixed, mesic	Udic Argiustolls	Mollisols.
Geary [3]	Fine-silty, mixed, mesic	Udic Argiustolls	Mollisols.
Haynie	Coarse-silty, mixed (calcareous), mesic	Typic Udifluvents	Entisols.
Hobbs	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Ida	Fine-silty, mixed (calcareous), mesic	Typic Udorthents	Entisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kipson	Loamy, mixed, mesic, shallow	Udorthentic Haplustolls	Mollisols.
Marshall [4]	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Mayberry	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Monona [5]	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Morrill [6]	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Onawa	Clayey over loamy, montmorillonitic (calcareous), mesic	Mollic Fluvaquents	Entisols.
Pawnee [7]	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Sharpsburg [8]	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Wabash	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
Wymore [9]	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Zook	Fine, montmorillonitic, mesic	Cumulic Haplaquolls	Mollisols.

[1] The placement of some soil series in the current system, particularly the placement in the families, may change as more precise information becomes available. The classification used here is current as of August, 1972.

[2] The Benfield soil in mapping unit BKB3 is a taxadjunct to the Benfield series, because it has a lighter colored upper horizon than is defined for the series.

[3] The Geary soil in mapping unit GeC3 is a taxadjunct to the Geary series, because it has a thinner, lighter colored A horizon than is defined in the range for the series.

[4] The Marshall soil in mapping unit MaC3 is a taxadjunct to the Marshall series, because it has a thinner, lighter colored A horizon than is defined in the range for the series.

[5] The Monona soils in mapping units MnC2, MnD2, and in some areas in mapping unit MnF, are taxadjuncts to the Monona series, because they have a thinner, lighter colored A horizon than is defined in the range for the series.

[6] The Morrill soils in mapping unit MC3 are taxadjuncts to the Morrill series, because they have a thinner, lighter colored A horizon than is defined in the range for the series.

[7] The Pawnee soil in mapping unit PaD3 is a taxadjunct to the Pawnee series, because it has a thinner, lighter colored A horizon than is defined in the range for the series.

[8] The Sharpsburg soil in unit ShC3 is a taxadjunct to the Sharpsburg series, because it has a thinner, lighter colored A horizon than is defined in the range for the series.

[9] The Wymore soil in unit Wt is a taxadjunct to the Wymore series, because it has a thicker A horizon and a darker upper B horizon than is defined in the range for the series. The Wymore soil in unit WtD3 is a taxadjunct to this series, because it has a thinner, lighter colored A horizon than is defined in the range for the series.

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

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

General Nature of the County

Indians were the only inhabitants of the territory that is now Richardson County before the first pioneers settled along Muddy Creek near the site of what is now Falls City in 1855. This was the start of the first prairie farm.

The first pioneers were hardy adventurers looking for new industry. Some coal was mined near the towns of Rulo and Humboldt, but the newcomers learned by need and by ample harvests that their greatest resource was the soil. They plowed soils that grew tall prairie grasses, and they planted patches of corn, wheat, potatoes, and other garden crops and berries and other fruits.

After surveyors measured square tracts of land, known as sections, and after homestead lands were taken, settlers bought land and built permanent homes. Eventually all of the area was farmed.

Physiography, Relief, and Drainage

Richardson County lies within the glaciated part of the physiographic province known as the Great Plains. It is part of a large, dissected plain where only small remnants of the original plain exist on the highest divides.

Underlying limestone and shale bedrock, now exposed in the southwestern part of the county, was deposited at the bottom of a sea that at one time covered the county. As the sea subsided, glaciers moved across the county, smoothing the land surface and churning large masses of earth material. As the climate became warmer, the glaciers melted and receded and left a glacial plain, which was eroded to produce the present landscape. Water erosion formed uplands, benchlike positions, and bottom lands.

Later, the landscape was somewhat modified by erosion of surface materials. Streams deposited alluvium in the valleys, and the wind picked up dust, known as loess, and settled it over most of the landscape. Deposits of dust were thickest near the larger valleys and on the smoothest parts of the uplands. In some places loess did not accumulate, or it was removed by erosion.

The uplands, by far the most extensive landscape features, are remnants of the original glacial plain. The few bench positions were once bottom lands that formed when streams were flowing at higher levels than at present. The present bottom lands include nearly all of the low positions adjacent to streams where soil material is deposited.

Relief ranges from nearly level to very steep. The nearly level uplands are small and in places rather irregular in outline because of the headward advance of numerous small drainageways. The rest of the county consists of a succession of ridges, slopes, and valleys. The ridges are rounded and gently sloping, the slopes to the valleys are moderately sloping to very steep, and the valleys are nearly level. The smaller drainageways are generally shallow, though in places they are sharply cut and have short, steep grades. The slopes along the larger streams are often abrupt in areas immediately bordering the bottom lands, but become gradual toward the crests of the divides. In most places, the relief is moderate behind the valley edges. The areas of strongest relief are in the bedrock uplands along the valley sides, along the Nemaha River, and in the loess uplands that border the Missouri River. The bottom lands are nearly level and range from a few rods wide along the smaller streams to about 2½ miles wide along the Nemaha River.

The highest elevation in Richardson County is 1,200 feet in the northwestern part; the lowest is 862 feet along the Missouri River in the southeastern part. Drainage is chiefly southeastward. The North Fork of the Big Nemaha River enters the west-central part of the county, and the South Fork enters the southwestern part. The Big Nemaha passes just south of Falls City and flows into the Missouri River southeast of Rulo. Muddy Creek enters the north-central part of the county and empties into the Big Nemaha east of Falls City. All the drainages in the county are a part of the Nemaha watershed, except in the eastern and northern edge of the county where small drains empty into the Missouri River. Nearly all of the rivers and major creeks flow constantly, except during prolonged droughts.

Water Supply

A sufficient supply of good-quality well water is available for use in farm households in most areas of the county. Large quantities suitable for use in municipalities or for irrigation are limited to certain areas.

Water for individual farms is generally obtained from perched water zones. Shallow wells, 25 to 100 feet deep, are developed in sand lenses of glacial deposits and in sandy alluvium of the stream valleys. Throughout most of the county, the amount of water available from these wells ranges from 1 to 10 gallons per minute with continuous pumping. These shallow wells depend upon recharge by seepage and percolation of the annual precipitation; therefore, prolonged drought may further reduce their output. In areas of shale and limestone in the southwestern part of the county, a water supply is difficult to develop. Wells in valley fill and springs or seeps produce some water for livestock.

Studies of ground water in Richardson County made by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey, have given some information on the availability of ground water. These studies indicate that before the glaciers advanced across Eastern Nebraska, streams had cut channels, which were later filled with glacial materials, into the bedrock. Where the buried channels contain sand and gravel, wells capable of producing several hundred gallons per minute can be developed. But these areas are limited and not completely defined. The town of Humboldt obtains its water from one of these ancient, deep stream channels located several miles north of the town. Some of the larger supplies of underground water are also available in the sandy alluvium of the Missouri River Valley. Falls City obtains its water from wells in the Missouri River Valley several miles east of the town.

Surface water is an important supplement to the ground water supply in Richardson County. Its use for livestock and recreation extends the limited supply of quality ground water for domestic use. Streams and ponds that are easily developed are widely used to supply water for livestock. Reservoirs have not been developed for municipal water supplies.

Minerals

In 1939, the first oil well was discovered about 2 miles west of Falls City. This led to the discovery of other oilfields in the county. Because these wells lacked natural gas, there were no spectacular gushers when the wells were drilled. At present there are several producing wells in the county, but production is limited.

The only other minerals in the county are limestone, which is quarried, and sandy material used mostly for road surfacing.

Transportation

Paved roads and highways connect the towns in the county, and two main railroad lines cross the county. As a result of the channel improvement of the Missouri River for navigation, shipping of grain by barge on the river has increased in recent years.

Climate [9]

Richardson County lies in the extreme southeast corner of Nebraska along the banks of the Missouri River, but the river does not have a noticeable effect on the general climate of the county. The effects of the Missouri and other rivers within the county are limited to their immediate environs and to the times when conditions in

[9] Prepared by RICHARD E. MYERS, Nebraska State climatologist, National Weather Service.

the lower layers of the atmosphere are calm and stable. The county lies near the center of the United States; therefore, the climate is of a continental character, and rather large changes in weather are frequent. However, because of the far southeastern location, it escapes some of the extreme variability that is experienced in some other sections of Nebraska. It lies in a favorable position in respect to the flow of moisture-laden winds from the Gulf of Mexico. In no year of record has less than 20 inches of moisture been recorded, and only about 1 year in 10 less than 25 inches.

Rains early in spring are generally slow and steady, often continuing for 1 or 2 days. As spring advances there is a sharp increase in the amount of precipitation and a corresponding increase in the proportion that falls during showers and thunderstorms. By May, most of the precipitation falls as showers. Thundershowers in spring and summer are severe at times and may be accompanied by local downpours, hail, and damaging winds. Nearly 1½ inches of rain falls in an hour on an average of once each year. The hailstorms generally are local in extent, of short duration, and produce damage in an extremely variable and spotted pattern. In the more intense storms, the center of the hail strips produces a total loss of crops.

Peak precipitation is reached about the middle of June. A marked decrease in shower activity follows from then until the third week in July, when the low point in summer precipitation is reached. Rainfall increases by the end of July and continues through August and early September before beginning a steady decline through fall and winter. Fall has many warm, bright, sunny days.

Winter precipitation is evenly distributed at the rate of slightly more than 1 inch per month. This is more than falls at points farther north and west in Nebraska. Because some of the winter precipitation falls as rain, the snowfall is not as heavy as in other areas of Nebraska. The snow seldom remains on the ground for long periods and frequently melts before the arrival of the next snowfall. In an average winter, snow covers the ground on only 35 days.

The average annual maximum temperature for Richardson County is 104° F.; the average annual minimum −12° F. The extreme maximum of 115° F., was recorded in 1934, and the extreme minimum of −30° F. was recorded in 1889.

Average monthly temperature and precipitation data for the county are given in table 8. The probabilities of freezing temperatures after specified dates in spring and before certain dates in fall are given in table 9.

Annual free-water evaporation from shallow lakes averages about 43 inches. Approximately 75 percent of the total evaporation occurs during the 6-month period May through October.

Farming

In earlier times, a large acreage in the county was planted to oats, barley, rye, and other small grain. These crops, however, are now of minor importance. With this exception, the proportions and kinds of crops have been fairly constant through the years. In recent years there has been an increase in the acreage planted to grain sorghum and soybeans, and at times there has been a considerable acreage of grasses and legumes sown for soil improvement. Fruits and garden crops are grown mainly

TABLE 8.—*Temperature and precipitation*

[All data from National Weather Service, Falls City, elevation 900 feet]

Month	Temperature				Precipitation				
	Average daily maximum [1]	Average daily minimum [1]	Two years in 10 will have at least 4 days with— [2]		Average monthly total [1]	One year in 10 will have— [3]		Days with 1 inch or more snow cover— [1]	Average depth of snow on days with snow cover— [1]
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—		Equal to or less than—	Equal to or more than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	36	16	56	−4	1.2	0.1	2.2	12	----------
February	42	20	62	1	1.3	.2	2.3	8	3
March	51	29	76	13	2.4	.4	3.8	5	5
April	66	41	84	27	3.0	1.1	5.5	(4)	2
May	76	52	90	38	4.7	1.6	7.7	0	----------
June	84	62	98	51	5.8	1.9	7.9	0	----------
July	90	66	104	55	3.7	1.1	7.0	0	----------
August	88	64	101	54	4.5	1.4	7.4	0	----------
September	81	55	98	42	4.1	1.2	7.8	0	----------
October	72	45	87	29	2.1	.7	4.6	(4)	1
November	53	31	72	14	1.6	.1	3.5	1	2
December	41	21	60	1	1.1	.2	2.0	8	4
Annual	65	42	[5] 104	[6] −12	35.6	25.0	43.6	35	4

[1] Data based on period 1937 through 1966.
[2] Data based on period 1903 through 1963.
[3] Data based on period 1884 through 1966.
[4] Less than half a day.
[5] Average annual maximum.
[6] Average annual minimum.

TABLE 9.—*Probabilities of selected freezing temperatures in spring and fall*

[All data from Falls City]

Probability	Dates for given probability and temperature				
	16° F.	20° F.	24° F.	28° F.	32° F.
Spring:					
1 year in 10 later than	March 30	April 7	April 15	April 27	May 10
2 years in 10 later than	March 24	April 2	April 10	April 21	May 4
5 years in 10 later than	March 14	March 23	March 31	April 11	April 24
Fall:					
1 year in 10 earlier than	November 7	October 29	October 18	October 9	September 29
2 years in 10 earlier than	November 13	November 3	October 24	October 15	October 4
5 years in 10 earlier than	November 24	November 12	November 2	October 25	October 14

for home use. Veneer, sawlogs, and fenceposts are also produced in the county, but wood products are only a small part of the farming enterprise.

The county is expected to remain an important farming area in which most farms continue as cash-grain farms, livestock farms, or a combination of these. The quality of mechanization and machine use is expected to improve. Development of recreation areas is expected along the very steep slopes that border the Missouri River and in other areas of the county.

Reports of the U.S. Census of Agriculture show that in 1964 there were 1,194 farms in Richardson County and that the average farm was 285.8 acres in size. Of these, 380 were cash-grain farms, 5 were poultry farms, 66 were dairy farms, 507 were livestock farms other than poultry or dairy (7 livestock ranches were included), and 67 were general farms. Not classified were 169 miscellaneous farms.

In 1964 about 97 percent of the county, or 341,258 acres, was rural. Of this acreage, about 71 percent, or 241,404 acres, was cropland; about 16 percent, or 54,523 acres, was pasture; and about 6 percent, or 21,340 acres, was woodland and pasture and woodland not pastured. The remaining 7 percent, or 23,991 acres, was in house lots, roads, and the like. Of the acreage classified as cropland, about 31 percent, or 75,818 acres, was not harvested but was used for temporary pasture and soil-improvement grasses and legumes.

The acreage of the principal crops grown in the county in 1964 was as follows:

	Number of farms	*Acres*
Corn harvested mainly for grain	981	79, 071
Sorghums harvested for grain	418	16, 300
Soybeans	594	18, 551
Wheat	791	24, 450
Alfalfa hay	801	13, 987
Clover hay	433	7, 084

Livestock has always been a major source of income in Richardson County. The number and principal kinds of livestock in the county in 1964 were as follows:

	Number of farms	*Number of livestock*
Cattle and calves	1, 025	61, 450
Milk cows	385	3, 551
Hogs and pigs	685	60, 542
Sheep and lambs	92	3, 416

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Glossary

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. The capacity of a soil to hold water available for use by plants, usually expressed in linear depths of water per unit depth of soil. Commonly defined as the difference between the percentage of soil water at field capacity and the percentage at wilting point. This difference multiplied by the bulk density and divided by 100 gives a value in inches of water per inch of soil. In this survey, the classes of available water capacity for a soil 60 inches deep, or to a limiting layer are:

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

Bench (geological). A terrace or plain, usually flat or undulating and marking the level of a former shoreline of a stream.

Buried soil. A developed soil, once exposed but now overlain by more recently formed soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Catsteps. Narrow steps on moderately steep and steep hillsides, caused by slumping or soil slippage.

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.

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.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

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

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

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

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

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

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

Depth, soil. The total thickness of weathered soil material overlying mixed sand and gravel or bedrock. In this survey, the classes of soil depth used are:

Inches	
0 to 5	Very shallow
5 to 20	Shallow
20 to 40	Moderately deep
More than 40	Deep

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 have 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.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

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

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

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

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

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

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

Leaching. The removal of soluble materials from soils or other material by percolating water.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone-derived materials applied to neutralize acid soils. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oystershells, and marl also contain calcium.

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

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

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Permeability. The quality that enables moist soil to transmit air and water. In this survey, terms used to describe permeability apply to that part of the soil below the Ap horizon or equivalent layer and above a depth of 60 inches, or to bedrock if it occurs above 60 inches. Where there is a change of two or more permeability classes within a short vertical distance, the classes and depths are stated. Classes of soil permeability are:

Inches per hour	
Less than 0.063	Very slow
0.063 to 0.20	Slow
0.20 to 0.63	Moderately slow
0.63 to 2.00	Moderate
2.00 to 6.30	Moderately rapid
6.30 to 20.00	Rapid
20.00 and higher	Very rapid

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

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

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff, surface. The water that flows on the land surface without sinking in.

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. A 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.

Slope. The degree of deviation of a surface from the horizontal, usually expressed in percent or degrees. In this survey, the following classes of slope are used:

Percent	
0 to 1	Nearly level.
1 to 3	Very gently sloping or very gently undulating.
3 to 5	Gently sloping or gently rolling.
5 to 9	Sloping or gently rolling and rolling.
9 to 12	Strongly sloping or rolling.
12 to 17	Moderately steep or hilly.
17 to 30	Steep or very hilly.
More than 30	Very steep.

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.

Stratified. Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geological material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

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 aggregated longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. In this survey, the B horizon; generally the part of the solum below plow depth.

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

Terrace. An embankment or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

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.

Underlying material. In this survey, the weathered soil material immediately beneath the solum.

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GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. In referring to a capability unit, read the introduction to the section it is in for general information about its management. Windbreak groups are described on pages 40, 41, and 42. Other information is given in tables as follows:

Acreage and extent, table 1, page 8.
Estimated yields, table 2, page 40.

Engineering uses of the soils, tables 4, 5, and 6, pages 46 through 61.

Map symbol	Mapping unit	Page	Capability unit: Symbol	Capability unit: Page	Range site: Name	Windbreak group: Name
Ak	Albaton silty clay-------------------------------	9	IIIw-1	36	Clayey Overflow	Moderately Wet
BfB2	Benfield silty clay loam, 3 to 9 percent slopes, eroded-------------------------------	10	IIIe-2	35	Clayey	Silty to Clayey
BKB3	Benfield-Kipson silty clay loams, 3 to 9 percent slopes, severely eroded---------------	10	IVe-4	36		
	Benfield soil------------------------------	--	------	--	Clayey	Silty to Clayey
	Kipson soil--------------------------------	--	------	--	Shallow Limy	Shallow
GeC2	Geary silty clay loam, 5 to 12 percent slopes, eroded--	11	IIIe-1	35	Silty	Silty to Clayey
GeC3	Geary silty clay loam, 5 to 12 percent slopes, severely eroded------------------------------	11	IVe-8	37	Silty	Silty to Clayey
GL	Gullied land-----------------------------------	11	VIIIe-1	39	---------------	Undesirable
HA	Haynie and Albaton soils -----------------------	12	IIw-3	35		
	Haynie soil--------------------------------	--	------	--	Silty Lowland	Moderately Wet
	Albaton soil-------------------------------	--	------	--	Clayey Overflow	Moderately Wet
He	Haynie silt loam--------------------------------	11	IIw-3	35	Silty Lowland	Moderately Wet
HS	Haynie and Sarpy soils -------------------------	12	IIw-3	35		
	Haynie soil--------------------------------	--	------	--	Silty Lowland	Moderately Wet
	Sarpy soil---------------------------------	--	------	--	Sandy Lowland	Sandy
Hv	Hobbs silt loam---------------------------------	12	IIw-3	35	Silty Lowland	Moderately Wet
IdD2	Ida silt loam, 12 to 17 percent slopes, eroded--	13	IVe-8	37	Limy Upland	Silty to Clayey
IdF2	Ida silt loam, 17 to 30 percent slopes, eroded--	13	VIe-8	38	Limy Upland	Silty to Clayey
JuA	Judson silt loam, 1 to 4 percent slopes---------	13	IIe-1	34	Silty Lowland	Silty to Clayey
KBD	Kipson-Benfield silty clay loams, 9 to 17 percent slopes ------------------------------	15	VIs-4	38		
	Kipson soil--------------------------------	--	------	--	Shallow Limy	Shallow
	Benfield soil------------------------------	--	------	--	Clayey	Silty to Clayey
Ke	Kennebec silt loam------------------------------	14	I-1	34	Silty Lowland	Silty to Clayey
KSD	Kipson-Sogn complex, 3 to 30 percent slopes-----	16	VIIs-3	39	Shallow Limy	Shallow
MaA	Marshall silty clay loam, 0 to 2 percent slopes-	16	I-1	34	Silty	Silty to Clayey
MaB	Marshall silty clay loam, 2 to 5 percent slopes-	17	IIe-1	34	Silty	Silty to Clayey
MaC2	Marshall silty clay loam, 5 to 12 percent slopes, eroded------------------------------	17	IIIe-1	35	Silty	Silty to Clayey
MaC3	Marshall silty clay loam, 5 to 12 percent slopes, severely eroded----------------------	17	IIIe-8	36	Silty	Silty to Clayey
MC2	Morrill soils, 5 to 12 percent slopes, eroded---	20	IIIe-1	35	Silty	Silty to Clayey
MC3	Morrill soils, 5 to 12 percent slopes, severely eroded------------------------------	20	IVe-8	37	Silty	Silty to Clayey
MD	Morrill soils, 12 to 17 percent slopes----------	21	IVe-1	36	Silty	Silty to Clayey
MnB	Monona silt loam, 1 to 5 percent slopes---------	18	IIe-1	34	Silty	Silty to Clayey

Map symbol	Mapping unit	Page	Capability unit: Symbol	Capability unit: Page	Range site: Name	Windbreak group: Name
MnC	Monona silt loam, 5 to 12 percent slopes----------	18	IIIe-1	35	Silty	Silty to Clayey
MnC2	Monona silt loam, 5 to 12 percent slopes, eroded--	18	IIIe-8	36	Silty	Silty to Clayey
MnD	Monona silt loam, 12 to 17 percent slopes---------	19	IVe-1	36	Silty	Silty to Clayey
MnD2	Monona silt loam, 12 to 17 percent slopes, eroded---	19	IVe-8	37	Silty	Silty to Clayey
MnF	Monona silt loam, 17 to 30 percent slopes---------	19	VIe-1	38	Silty	Silty to Clayey
Nd	Nodaway silt loam---------------------------------	22	I-1	34	Silty Lowland	Silty to Clayey
Oc	Onawa silty clay----------------------------------	22	IIIw-1	36	Clayey Overflow	Moderately Wet
PAC2	Pawnee and Mayberry clay loams, 3 to 9 percent slopes, eroded---------------------------------	24	IIIe-2	35	Clayey	Silty to Clayey
PAD2	Pawnee and Mayberry clay loams, 9 to 12 percent slopes, eroded---------------------------------	24	IVe-2	36	Clayey	Silty to Clayey
PAD3	Pawnee and Mayberry clay loams, 3 to 12 percent slopes, severely eroded------------------------	24	IVe-4	36	Dense Clay	Silty to Clayey
RB	Rough broken land---------------------------------	24	VIIe-1	38	Savannah	Undesirable
Sg	Sarpy loamy fine sand-----------------------------	25	IVs-5	37	Sandy Lowland	Sandy
ShA	Sharpsburg silty clay loam, 0 to 2 percent slopes---	26	I-1	34	Silty	Silty to Clayey
ShB2	Sharpsburg silty clay loam, 2 to 5 percent slopes, eroded---------------------------------	26	IIe-1	34	Silty	Silty to Clayey
ShC2	Sharpsburg silty clay loam, 5 to 12 percent slopes, eroded---------------------------------	26	IIIe-1	35	Silty	Silty to Clayey
ShC3	Sharpsburg silty clay loam, 3 to 12 percent slopes, severely eroded------------------------	26	IIIe-8	36	Silty	Silty to Clayey
Sy	Silty alluvial land-------------------------------	26	VIw-1	38	Silty Overflow	Moderately Wet
SZ	Slickspots-Wabash complex-------------------------	26	IVs-1	37	Clayey Overflow	Moderately Saline or Alkali
Wa	Wabash silty clay---------------------------------	28	IIIw-1	36	Clayey Overflow	Moderately Wet
Ws	Wabash silty clay loam----------------------------	28	IIw-2	34	Clayey Overflow	Moderately Wet
Wt	Wymore silty clay loam, 0 to 1 percent slopes-----	30	IIs-2	34	Clayey	Silty to Clayey
WtA	Wymore silty clay loam, 1 to 3 percent slopes-----	30	IIe-2	34	Clayey	Silty to Clayey
WtC	Wymore silty clay loam, 3 to 9 percent slopes-----	30	IIIe-2	35	Clayey	Silty to Clayey
WtC2	Wymore silty clay loam, 3 to 9 percent slopes, eroded---	30	IIIe-2	35	Clayey	Silty to Clayey
WtD2	Wymore silty clay loam, 9 to 12 percent slopes, eroded---	30	IVe-2	36	Clayey	Silty to Clayey
WtD3	Wymore silty clay loam, 3 to 12 percent slopes, severely eroded-------------------------------	30	IVe-4	36	Dense Clay	Silty to Clayey
Wx	Wet alluvial land---------------------------------	29	Vw-1	37	Wet Land	Very Wet
Zo	Zook silty clay loam------------------------------	31	IIw-4	35	Clayey Overflow	Moderately Wet

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