SOIL SURVEY OF

Page County, Iowa

United States Department of Agriculture
Soil Conservation Service
in cooperation with
Iowa Agriculture and
Home Economics Experiment Station,
Cooperative Extension Service,
Iowa State University and the
Department of Soil Conservation, State of Iowa

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

Major fieldwork for this soil survey was completed in the period 1967 to 1972. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1970. This survey was made cooperatively by the Soil Conservation Service, Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Page County Soil and Water Conservation District.

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

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, woodlands, and wildlife areas; 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 Page County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

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

Finding and Using Information

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 discussion of woodland types.

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

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife habitat."

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the sections "Engineering" and "Recreation."

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

Scientists and others can read about the soils in the section "Formation and classification of soils."

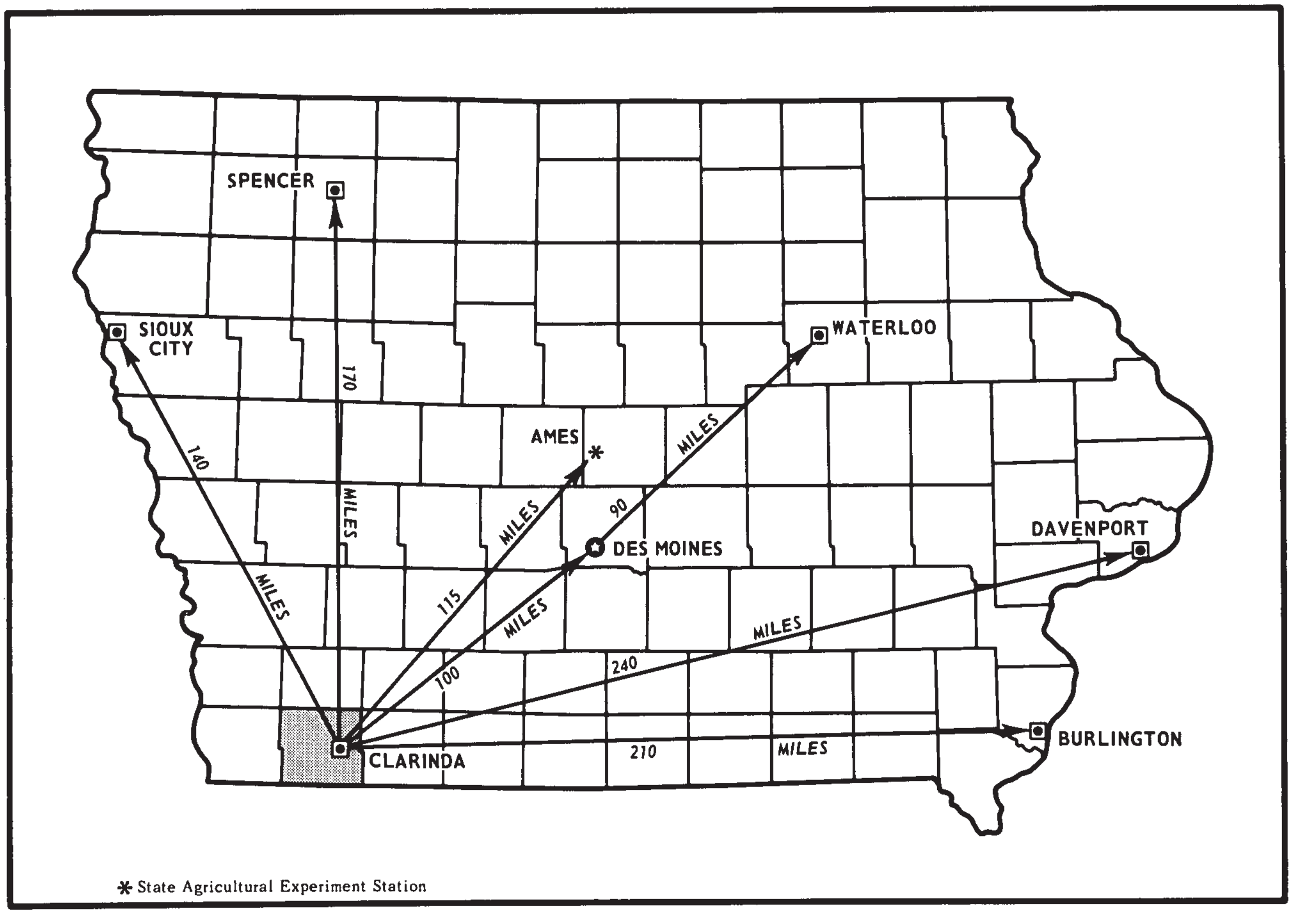
Newcomers in the area may be interested in the section "General soil map," where broad patterns of soils are described. They may also be interested in the information about the county in the section "General nature of the county."

Cover: The grassed-backslope terraces help control erosion and the pond provides water storage and recreation. The soils are Marshall, Adair, and Colo-Judson.

Table of Contents

Issued June 1978

Index to mapping units



Location of Page County in Iowa.

SOIL SURVEY OF PAGE COUNTY, IOWA

By Lewis A. Clark and Kendall M. McWilliams

Soils surveyed by Lewis A. Clark, Dennis W. Bryant, Wayne N. Dankert, Robert O. Dideriksen, Kendall M. McWilliams, Gerald A. Miller, and John R. Nixon, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with the Iowa Agriculture and Home Economics Experiment Station, Cooperative Extension Service, Iowa State University and the Iowa Department of Soil Conservation, State of Iowa

PAGE COUNTY is in the southwestern part of Iowa. It has a total land area of 535 square miles, or 342,400 acres. Clarinda, the county seat, is about 95 miles southwest of Des Moines, the state capital.

Most of the acreage is agricultural, and the population is rural. Corn, soybeans, hay, and pasture are the main crops. Much of the corn and forage crops are fed to hogs and beef cattle. Nursery stock is grown in the western part of the county and is important to the local economy.

Most of the soils in the survey area formed under prairie vegetation. The climate is subhumid and continental. Winters are cold, summers are warm, and the growing season is long enough for crops to mature.

The major hazard to the soils is erosion. Most of the soils are suited to row crops if erosion is controlled, but some are best suited to hay or pasture.

How this survey was made

Soil scientists made this survey to learn what kinds of soil are in Page County, where they are located, and how they can be used. They 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 nearby counties and in more distant places. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles that are 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 geographic feature near the place where a soil of that series was first observed and mapped. Sharpsburg and Shelby, 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 layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Sharpsburg silty clay loam, 5 to 9 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 woodland, buildings, field borders, and other details that help in drawing boundaries accurately. The soil map at 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 impractical 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.

A soil complex consists of areas of two or more soils, so intermingled or so small 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 proportion 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, for example, Shelby-Adair clay loams, 9 to 14 percent slopes.

In most areas surveyed there 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 miscellaneous areas and are given descriptive names such as "Alluvial land, sandy," which is a miscellaneous area in Page County.

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

But only part of a soil survey is completed 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. Farmers, managers of woodland and rangeland, and engineers are among the users.

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 they adjust the groups according to the results. Thus, the groups that finally evolve 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 the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. Typically, it consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in an association can occur in other associations but in different patterns.

A map showing soil associations is useful to people who want to have a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to locate large tracts that are suitable for a certain kind of land use. Such a map is a useful guide for broad planning of a watershed, a wooded tract, or a wildlife area or for broad planning of recreation facilities, community developments, and such engineering works as transportation corridors. It is not suitable for detailed planning of management of a farm or field or for selecting the exact location of a road or building or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in this survey area are described on the pages that follow.

1. Marshall association

Gently sloping to strongly sloping, well drained soils that are silty clay loam throughout

This association is on most uplands in the western half of the survey area. It is made up of gently sloping ridgetops and moderately sloping and strongly sloping side slopes. The difference in elevation between the ridgetops and the base of the side slopes is 40 to 60 feet. This association has a well developed drainage system (fig. 1).

This association makes up about 36 percent of the survey area. It is about 60 percent Marshall soils and about 40 percent minor soils.

Marshall soils are gently sloping to strongly sloping. They are on ridgetops and side slopes and are well drained. Typically, the surface layer is very dark brown silty clay loam about 15 inches thick. The subsoil is about 33 inches thick. It is dark brown silty clay loam in the upper part; in the lower part it is brown silty clay loam that has light gray, grayish brown, and yellowish brown mottles. The underlying material is light brownish gray silty clay loam with brown mottles.

Minor soils in this association are Adair, Shelby, Colo, and Judson soils. Adair soils are on the lower side slopes and are moderately well drained or somewhat poorly drained. Shelby soils are on slightly steeper, lower side slopes and are moderately well drained. Colo and Judson soils formed in alluvium in drainageways.

Corn, soybeans, small grain, and hay grow well on soils of this association. The available water capacity is high, and the organic-matter content is moderate on uneroded soils. The main concern of management is controlling erosion (fig. 2).

Marshall, Colo, and Judson soils are used for cultivated crops. Adair and Shelby soils are used mostly for pasture and hay. The main enterprises are growing cash crops and raising livestock. The soils are suited to all cultivated crops commonly grown in the county.

2. Nevin-Marshall association

Nearly level and gently sloping, somewhat poorly drained and well drained soils that are silty clay loam throughout

This association consists of loess and alluvial benches or second bottoms along the East Nishnabotna River. The benches, which are between alluvial first bottoms and uplands, are nearly level to gently sloping.

This association makes up about 2 percent of the survey area. It is about 33 percent Nevin soils, 31 percent Marshall soils, and 36 percent minor soils.

Nevin soils are nearly level. They are on low benches and are somewhat poorly drained. Typically, the surface layer is black and very dark grayish brown silty clay loam about 24 inches thick. The subsoil is dark grayish brown in the upper part and grayish brown in the lower part. The subsoil is silty clay loam and extends to a depth of 60 inches.

Marshall soils are nearly level or gently sloping. They are on benches and are well drained. Typically, the surface layer is very dark brown silty clay loam about 15 inches thick. The subsoil is about 33 inches thick. It is dark brown silty clay loam in the upper part; in the lower part it is brown silty clay loam that has light gray, grayish brown, and yellowish brown mottles. The underlying material is light brownish gray silty clay loam and has brown mottles.

The minor soils in this association are Minden and Bremer soils. Minden soils are on broad, nearly level areas that are somewhat poorly drained. Bremer soils are in slight depressions and are poorly drained.

Corn, soybeans, small grain, and hay grow well on the soils of this association. The available water

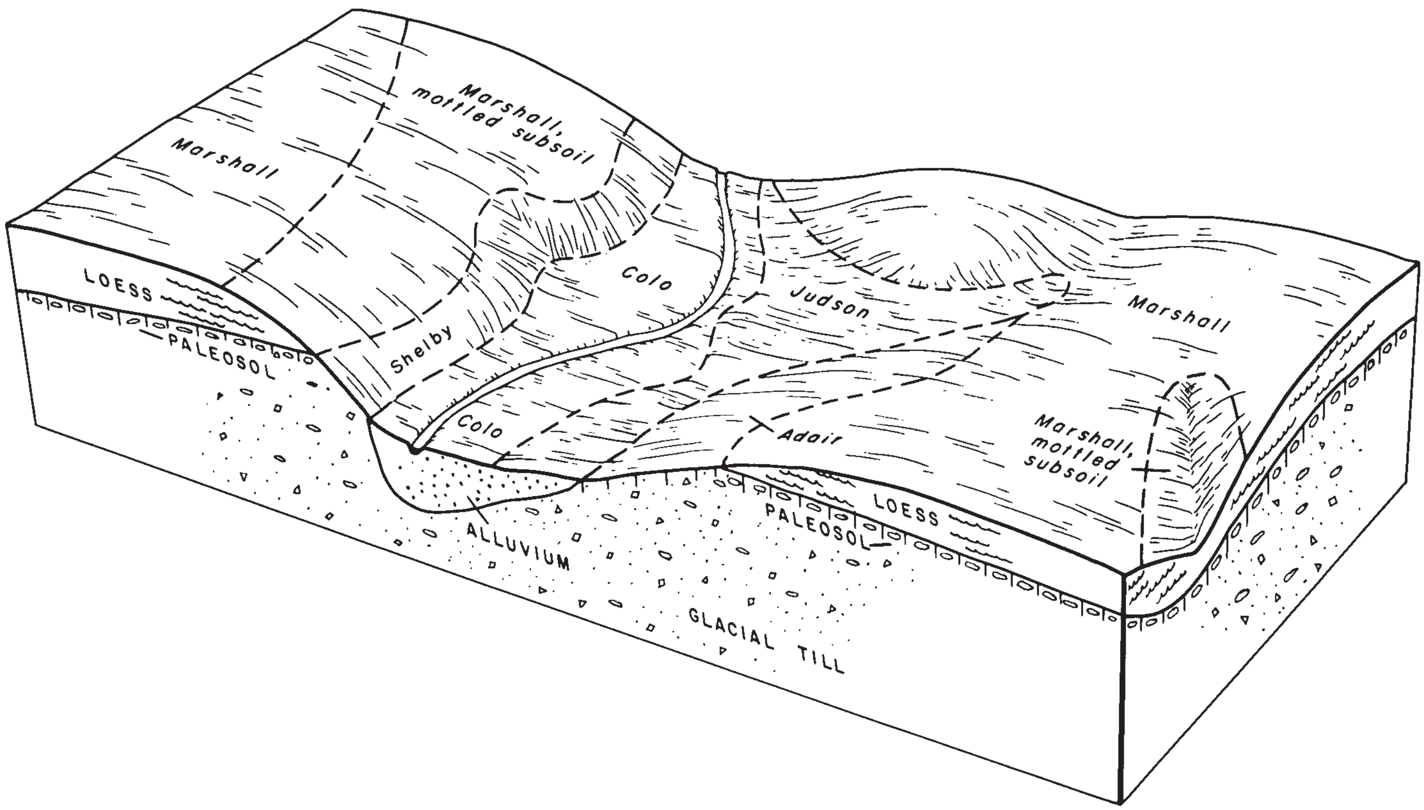


***Figure 1.*—Slope and parent material of soils in the Marshall soil association.**

capacity is high, and the organic-matter content is moderate to high. The main concern of management is maintaining fertility. Nearly all of this association is used for row crops. The main enterprise is growing cash crops and raising nursery stock. The soils are suited to all cultivated crops commonly grown in the county.

3. Sharpsburg association

Nearly level to strongly sloping, moderately well drained soils that are silty clay loam throughout

This association is on most uplands in the eastern half of the survey area. It is made up of nearly level and sloping ridgetops and moderately sloping and strongly sloping side slopes. The difference in elevation from the base of the side slopes to the ridgetops is 40 to 60 feet. This association has a well developed drainage system.

This association makes up about 30 percent of the survey area. It is about 54 percent Sharpsburg soils and 46 percent minor soils.

Sharpsburg soils are nearly level to strongly sloping. They are on ridgetops and side slopes and are moderately well drained. Typically, the surface layer is very dark gray silty clay loam about 16 inches thick. The subsoil is very dark grayish brown silty clay loam in the upper part, brown to dark yellowish brown silty clay loam in the middle part, and mottled grayish brown and dark yellowish brown silty clay loam in the lower part. It is about 40 inches thick. The underlying material is light brownish gray and brown silty clay loam.

The minor soils in this association are Adair, Shelby, Colo, and Judson soils. Adair soils are on the lower side slopes and are moderately well drained or somewhat poorly drained. Shelby soils are on the slightly steeper, lower side slopes and are moderately well drained. Colo and Judson soils are somewhat poorly drained or poorly drained and formed in alluvium in drainageways.

Corn, soybeans, small grain, and hay grow well on soils of this association. The available water capacity is high, and the organic-matter content is moderate on uneroded soils. The main concern of management is controlling erosion.

Sharpsburg, Colo, and Judson soils are used for cultivated crops. Adair and Shelby soils are used mostly for pasture and hay crops. The main enterprises are growing cash crops and raising livestock. The soils are suited to all cultivated crops commonly grown in the county.

4. Sharpsburg-Winterset-Macksburg association

Nearly level to moderately sloping, moderately well drained to poorly drained soils that have a surface layer of silty clay loam

This association consists of loess benches and second bottoms along the Nodaway Rivers. The benches, which are between alluvial first bottoms and uplands, are nearly level to moderately sloping.

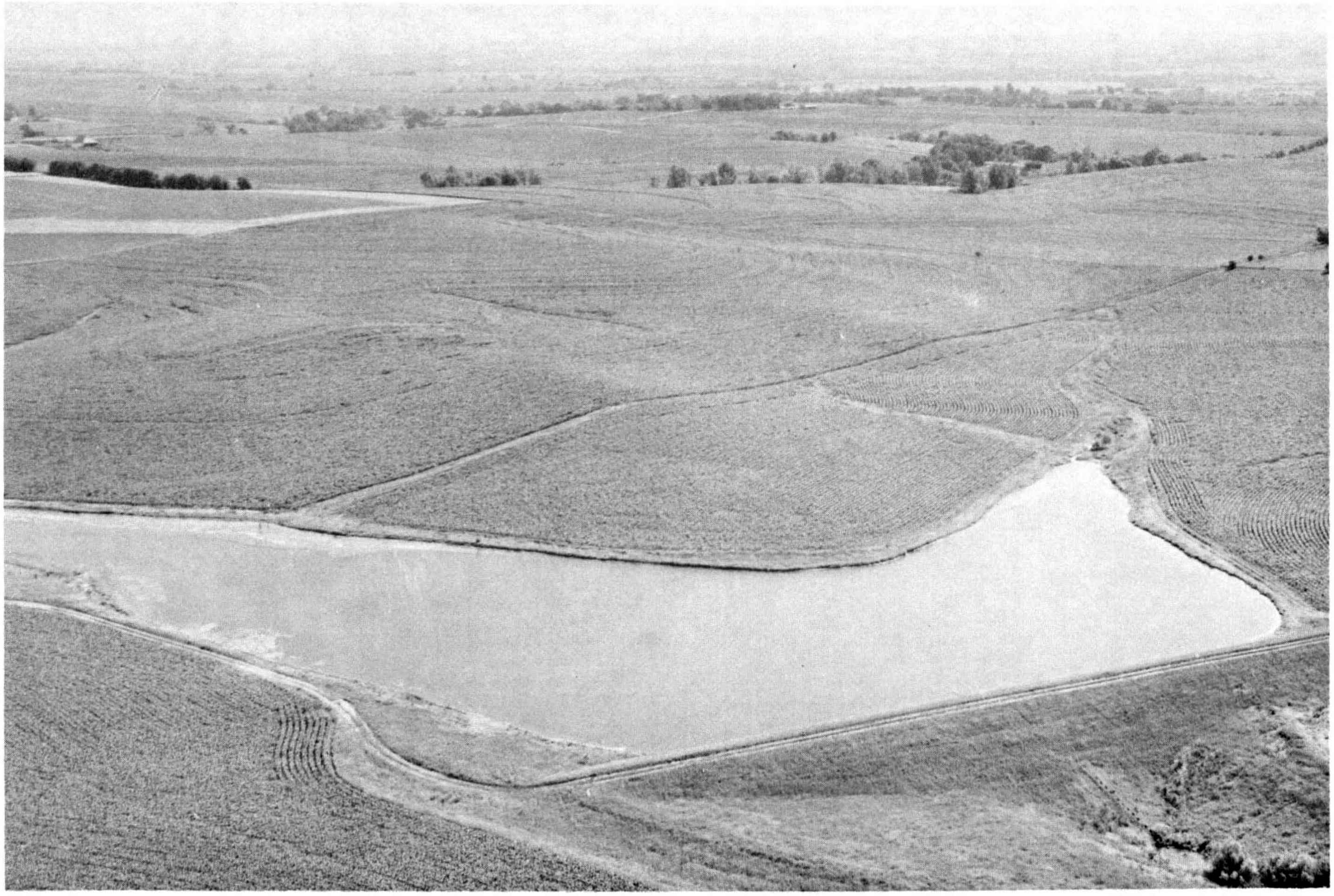


Figure 2.—**A pond in the Marshall soil association used to store water and control gullies.**

This association makes up about 4 percent of the survey area. It is about 32 percent Sharpsburg soils, 26 percent Winterset soils, 14 percent Macksburg soils, and 28 percent minor soils.

Sharpsburg soils are gently sloping and moderately sloping. They are on benches and on the short side slopes of benches. They are moderately well drained. Typically, the surface layer is very dark gray silty clay loam about 20 inches thick. The subsoil is very dark grayish brown silty clay loam in the upper part, brown to dark yellowish brown silty clay loam in the middle part, and mottled grayish brown and dark yellowish brown silty clay loam in the lower part. It is about 40 inches thick. The underlying material is light brownish gray and brown silty clay loam.

Winterset soils are nearly level. They are on benches, mainly in drainageways or depressions that are at a slightly lower elevation than Sharpsburg or Macksburg soils. Winterset soils are poorly drained. Typically, the surface layer is black in the upper part, very dark brown in the middle part, and very dark gray in the lower part. It is light silty clay loam in the upper part grading to medium silty clay loam in the lower part. The surface layer is about 24 inches thick. The subsoil, which extends to a depth of about 48 inches, is dark gray and very dark gray light silty clay or heavy silty clay loam. The underlying material is light olive gray and strong brown medium silty clay loam.

Macksburg soils are nearly level. They are on benches, generally at a slightly higher elevation than Sharpsburg and Winterset soils. Macksburg soils are somewhat poorly drained. Typically, the surface layer is black light silty clay loam about 20 inches thick. The subsoil, which extends to a depth of 48 inches, is very dark grayish brown medium silty clay loam in the upper part, dark grayish brown, grayish brown, and brown light silty clay or heavy silty clay loam in the middle part, and grayish brown medium silty clay loam in the lower part. The underlying material is grayish brown light silty clay loam.

The minor soils in this association are Nevin and Bremer soils. These soils are on low benches that are mainly near the river or its larger tributaries. Nevin soils are somewhat poorly drained, and Bremer soils are poorly drained.

Corn, soybeans, small grain, and hay grow well on soils of this association (fig. 3). The available water capacity is high, and the organic-matter content is moderate to high. The main concerns of management are maintaining fertility and providing adequate drainage in poorly drained areas.

Nearly all of this association is used for cultivated crops, mainly cash crops. The soils have a high potential for all cultivated crops grown in the survey area.

5. Sharpsburg-Shelby-Adair association

Nearly level to steep, moderately well drained and somewhat poorly drained soils that have a surface layer of silty clay loam or clay loam

This association is on uplands in the southwestern part of the survey area (fig. 4). It is made up of gently sloping ridgetops and moderately sloping to steep side slopes (fig. 5). The difference in elevation from the base of the side slopes to the ridgetops is 40 to 60 feet. This association has a well developed drainage system.

This association makes up about 11 percent of the survey area. About 45 percent of the association is Sharpsburg soils, 18 percent is Shelby soils, 14 percent is Adair soils, and 23 percent is minor soils.

Sharpsburg soils are on ridgetops and side slopes. They are nearly level to strongly sloping and are moderately well drained. Typically, the surface layer is very dark gray silty clay loam about 16 inches thick. The subsoil is very dark grayish brown silty clay loam in the upper part, brown to dark yellowish brown silty clay loam in the middle part, and mottled grayish brown and dark yellowish brown silty clay loam in the lower part. It is about 40 inches thick. The underlying material is light grayish brown and brown silty clay loam.

Shelby soils are on the lower side slopes below

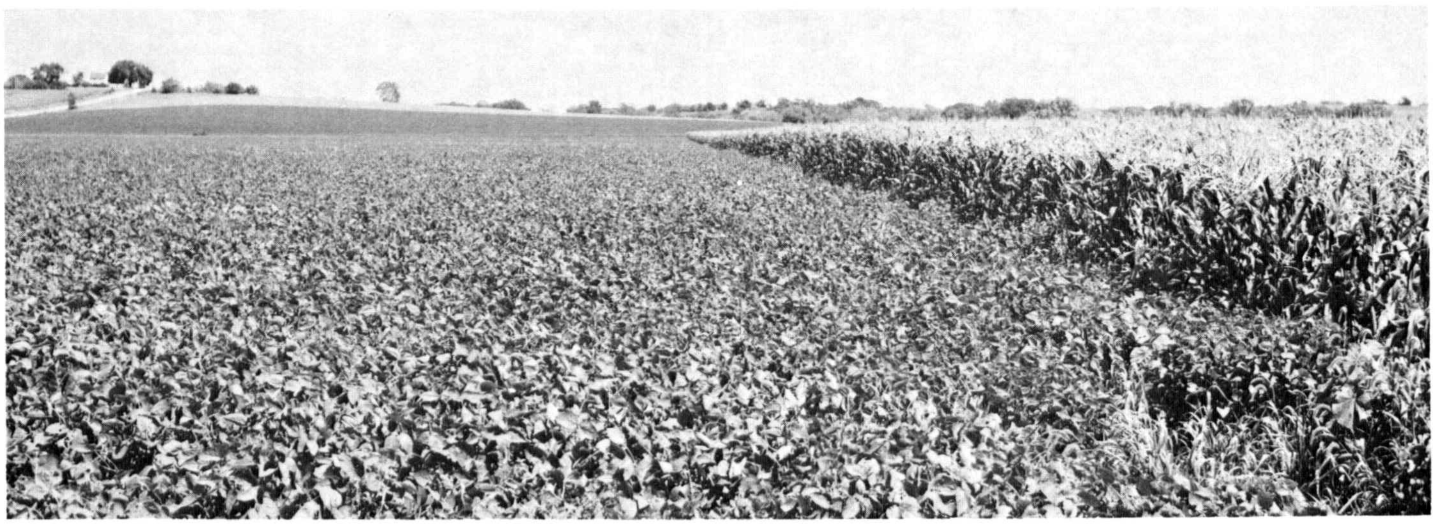


Figure 3.—**Corn and soybeans on Macksburg soils in the Sharpsburg-Winterset-Macksburg soil association.**

Figure 4.—**Typical landscape in the Sharpsburg-Shelby-Adair soil association.**

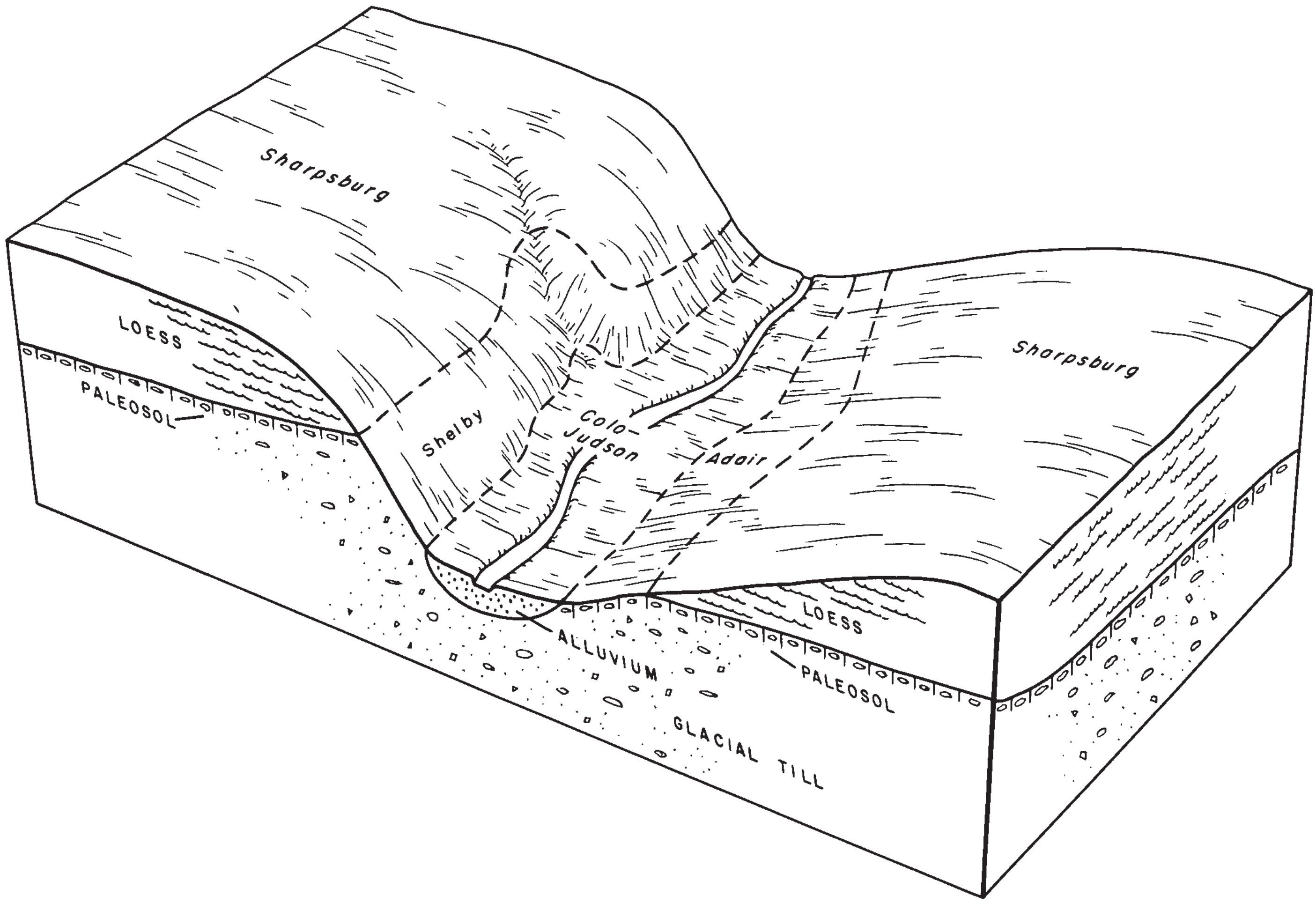


***Figure 5.*—Slope and parent material of soils in the Sharpsburg-Shelby-Adair soil association.**

Sharpsburg soils. These soils are strongly sloping to steep and moderately well drained. Typically, the surface layer is black or very dark brown clay loam about 10 inches thick. The subsoil is very dark grayish brown, brown, and dark yellowish brown clay loam about 28 inches thick. The underlying material is brown and light brownish gray clay loam.

Adair soils are moderately sloping and strongly sloping. They are on the lower side slopes along the smaller drainageways, slightly higher in elevation than Shelby soils and downslope from Sharpsburg soils. Adair soils are moderately well drained or somewhat poorly drained. Typically, they have a 14-inch surface layer that is very dark gray clay loam in the upper part and brown clay loam in the lower part. The subsoil is brown clay loam in the upper part, strong brown, grayish brown, and reddish brown heavy clay loam and silty clay in the middle part, and yellowish brown, strong brown, and grayish brown clay loam in the lower part. It extends to a depth of 60 inches.

The minor soils in this association are Colo and Judson soils, which formed in alluvium in drainageways and are moderately well drained to poorly drained.

Corn, soybeans, small grain, and hay grow well on soils of this association. The available water capacity is high, and the organic-matter content is moderate on uneroded soils. The main concern of management is controlling erosion.

Sharpsburg, Colo, and Judson soils are used for cultivated crops. Adair and Shelby soils are used for pasture and hay crops. The main enterprises are growing cash crops and raising livestock. The soils are suited to all cultivated crops commonly grown in the survey area.

6. Gara-Ladoga association

Gently sloping to very steep, well drained and moderately well drained soils that have a surface layer of loam or silt loam

This association is on the steeper parts of the uplands along the Nodaway Rivers in the eastern part of the county. It is made up of narrow, gently sloping and moderately sloping ridgetops and strongly sloping to very steep side slopes (fig. 6). The difference in elevation from the base of the side slopes to the ridgetops is about 40 to 60 feet. The soils in this association are generally covered with mixed timber and grass or have been recently cleared.

This association makes up about 3 percent of the survey area. It is about 51 percent Gara soils, 37 percent Ladoga soils, and 12 percent minor soils.

Gara soils are on side slopes. They are well drained or moderately well drained and are strongly sloping to very steep. Typically, the surface layer is very dark gray loam about 7 inches thick, and the subsurface layer is dark grayish brown loam about 5 inches thick. The subsoil extends to a depth of 46 inches. It is brown clay loam in the upper part and dark yellowish brown clay loam with yellowish brown and light olive gray mottles in the middle part. The lower part of the subsoil and the underlying material are yellowish brown and light olive gray clay loam.

Ladoga soils are gently sloping and moderately sloping on ridgetops and strongly sloping on upper side slopes. They are moderately well drained. Typically, the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsurface layer is dark grayish brown silt loam about 4 inches thick. The subsoil is brown silty clay loam in the upper part, brown silty clay loam and silty clay with light brownish gray silt coats and strong brown mottles in the middle part, and light brownish gray and strong brown silty clay loam in the lower part. The underlying material is light brownish gray silty clay loam that has strong brown mottles.

The minor soils in this association are Colo, Judson, Sharpsburg, and Shelby soils. Colo soils formed in silty clay loam alluvium near the small stream channels. Judson soils formed in silty alluvium and are on alluvial fans and foot slopes adjacent to uplands. Sharpsburg soils formed in loess under prairie vegetation. They occupy similar positions on the landscape as Ladoga soils. Shelby soils formed in glacial till under prairie vegetation. Sharpsburg and Shelby soils occur intermittently within the Gara-Ladoga association.

Row crops and hay are grown on the less sloping soils of this association. The steeper soils are generally in scrub timbers and are pastured. The available water capacity is high, and the organic-matter content is moderate to moderately low. The main concern of management is controlling erosion.

The main enterprise is raising beef cattle. The less sloping soils are suited to pasture and hay production.

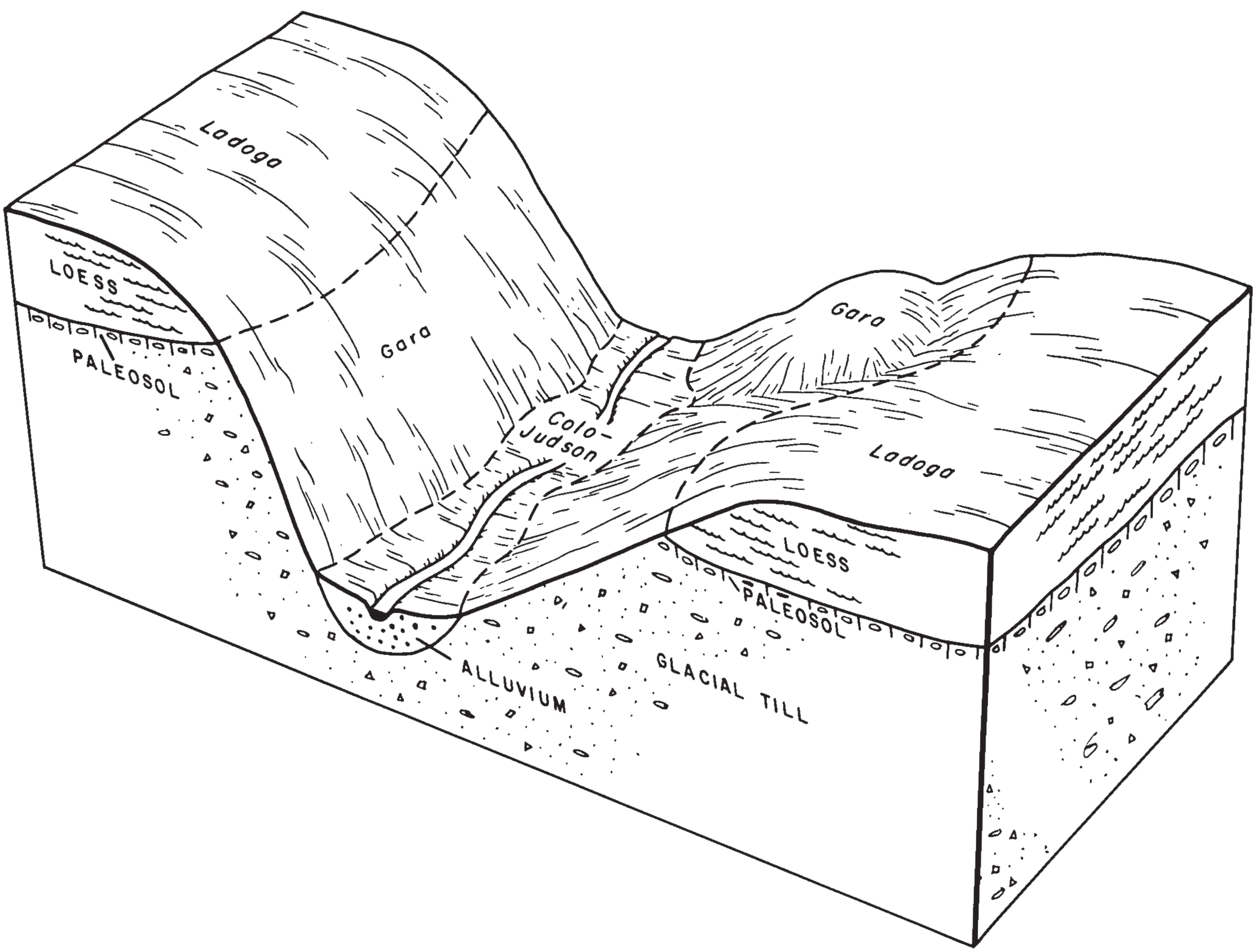


Figure 6.—**Slope and parent material of soils in the Gara-Ladoga soil association.**

The steeper soils are best suited to wildlife areas or timber production.

7. Colo-Kennebec-Nodaway association

Nearly level, moderately well drained and poorly drained soils that have a surface layer of silt loam or silty clay loam

This association consists of alluvial soils on flood plains or first bottoms along the larger streams and rivers. It makes up about 14 percent of the survey area. It is about 21 percent Colo soils, 20 percent Kennebec soils, 17 percent Nodaway soils, and 42 percent minor soils.

Colo soils are nearly level and are poorly drained. They formed in silty clay loam alluvium. Typically, the surface layer is black silty clay loam or very dark grayish brown silt loam in the upper part and black to very dark gray silty clay loam in the lower part. It is about 29 inches thick. The underlying material is silty clay loam that is black to very dark gray in the upper part and dark gray in the lower part.

Kennebec soils are nearly level and moderately well drained. They formed in silt loam alluvium. Typically, the surface layer is very dark brown or black silt loam about 36 inches thick. The layer below that is black silt loam about 9 inches thick. The underlying material is very dark gray silty clay loam.

Nodaway soils are nearly level and moderately well drained. They formed in recent silt loam alluvium. These soils are generally adjacent to stream channels. The surface layer is very dark grayish brown silt loam about 8 inches thick. The underlying material is stratified very dark grayish brown, dark grayish brown, and grayish brown silt loam.

The minor soils in this association are Judson, Wabash, and Zook soils. Judson soils are well drained or moderately well drained. They are on alluvial fans adjacent to uplands. Wabash and Zook soils are very poorly drained and poorly drained. They are generally at some distance from the stream channel.

Corn, soybeans, small grain, and hay grow well on soils of this association. The available water capacity is high, and the organic-matter content is low to high. The main concern of management is improving drainage and preventing floods.

All of this association is used for row crops. The main enterprise is cash crops. The soils are suited to all cultivated crops grown in the county.

Descriptions of the soils

This section describes each soil series in detail and then, briefly, each mapping unit in that series. Unless stated otherwise, 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 series is the soil profile, that is, the sequence of layers from the surface down to rock or other underlying material. Each series contains two descriptions of the profile. The first description is brief and in terms familiar to a layman. The second is more detailed and is included for those who need to make thorough and precise studies of soils. The profile described for the series is representative of mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, the differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for moist soil unless otherwise stated.

As mentioned in the section "How this survey was made," not all mapping units are members of a soil series. Alluvial land, sandy, for example, does not belong to a soil series; nevertheless, it is listed in alphabetic order with the soil series.

Preceding the name of each mapping unit is a symbol that identifies it on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which it has been placed.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping are in the Soil Survey Manual (*20*).[1]

Adair series

The Adair series consists of moderately well drained and somewhat poorly drained soils on ridgetops and convex side slopes. Adair soils formed in weathered glacial till under native vegetation of prairie grasses. Slopes are 5 to 18 percent.

In a representative profile the surface layer is clay loam that is very dark gray in the upper part and brown in the lower part. It is about 14 inches thick. The subsoil extends to a depth of 60 inches. It is brown clay loam in the upper part; strong brown, grayish brown, and reddish brown heavy clay loam and silty clay in the middle part; and yellowish brown, strong brown, and grayish brown clay loam in the lower part.

Permeability is slow, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is very low. The organic-matter content is 2 to 4 percent.

Adair soils are used primarily for pasture or hay crops. Erosion is the main hazard.

Representative profile of Adair clay loam, 9 to 14 percent slopes, in pasture, 1,156 feet north and 2,148 feet east of the southeastern corner of sec. 33, T. 70 N., R. 37 W.

A11—0 to 10 inches; very dark gray (10YR 3/1) light clay loam, gray (10YR 5/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; many fine roots; medium acid; gradual smooth boundary.

A12—10 to 14 inches; brown (7.5YR 4/4) light clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak fine

[1] Italic numbers in parentheses refer to References, p. 81.

TABLE 1.—*Acreage and proportionate extent of the soils*

Map symbol	Soil name	Acres	Percent
8B	Judson silty clay loam, 2 to 5 percent slopes	6,840	2.0
9B	Marshall silty clay loam, 2 to 5 percent slopes	17,767	5.2
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	1,487	0.4
9C	Marshall silty clay loam, 5 to 9 percent slopes	4,021	1.2
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	3,178	0.9
T9	Marshall silty clay loam, 0 to 2 percent slopes	852	0.2
T9B	Marshall silty clay loam, 2 to 5 percent complex slopes	960	0.3
11B	Colo-Judson silty clay loams, 2 to 5 percent slopes	60,185	17.6
24D	Shelby clay loam, 9 to 14 percent slopes	8,098	2.4
24D2	Shelby clay loam, 9 to 14 percent slopes, moderately eroded	7,749	2.3
24E	Shelby clay loam, 14 to 18 percent slopes	1,765	0.5
24E2	Shelby clay loam, 14 to 18 percent slopes, moderately eroded	1,088	0.3
24F2	Shelby clay loam, 18 to 25 percent slopes, moderately eroded	370	0.1
41D	Sparta loamy fine sand, 5 to 14 percent slopes	240	0.1
43	Bremer silty clay loam, 0 to 2 percent slopes	1,155	0.3
54	Zook silty clay loam, 0 to 2 percent slopes	5,039	1.5
54+	Zook silt loam, overwash, 0 to 2 percent slopes	571	0.2
76B	Ladoga silt loam, 2 to 5 percent slopes	470	0.1
76C	Ladoga silt loam, 5 to 9 percent slopes	596	0.2
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	705	0.2
76D	Ladoga silt loam, 9 to 14 percent slopes	908	0.3
76D2	Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	1,528	0.4
88	Nevin silty clay loam, 0 to 2 percent slopes	2,972	0.9
93D	Shelby-Adair clay loams, 9 to 14 percent slopes	950	0.3
93D2	Shelby-Adair clay loams, 9 to 14 percent slopes, moderately eroded	1,641	0.5
93E2	Shelby-Adair clay loams, 14 to 18 percent slopes, moderately eroded	259	0.1
99C	Marshall silty clay loam, mottled subsoil, 5 to 9 percent slopes	3,555	1.0
99C2	Marshall silty clay loam, mottled subsoil, 5 to 9 percent slopes, moderately eroded	8,988	2.6
99D	Marshall silty clay loam, mottled subsoil, 9 to 14 percent slopes	9,304	2.7
99D2	Marshall silty clay loam, mottled subsoil, 9 to 14 percent slopes, moderately eroded	29,503	8.6
133	Colo silty clay loam, 0 to 2 percent slopes	7,922	2.3
133+	Colo silt loam, overwash, 0 to 2 percent slopes	4,534	1.3
172	Wabash silty clay, 0 to 2 percent slopes	2,148	0.6
179D	Gara loam, 9 to 14 percent slopes	1,437	0.4
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded	1,529	0.4
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded	1,483	0.4
179F2	Gara loam, 18 to 25 percent slopes, moderately eroded	1,222	0.4
179G2	Gara loam, 25 to 40 percent slopes, moderately eroded	767	0.2
192C	Adair clay loam, 5 to 9 percent slopes	546	0.2
192C2	Adair clay loam, 5 to 9 percent slopes, moderately eroded	880	0.3
192D	Adair clay loam, 9 to 14 percent slopes	6,989	2.0
192D2	Adair clay loam, 9 to 14 percent slopes, moderately eroded	11,835	3.5
212	Kennebec silt loam, 0 to 2 percent slopes	11,096	3.2
220	Nodaway silt loam, 0 to 2 percent slopes	9,864	2.9
248	Wabash silty clay loam, 0 to 2 percent slopes	3,619	1.1
248+	Wabash silt loam, overwash, 0 to 2 percent slopes	874	0.3
273B	Olmitz loam, 2 to 5 percent slopes	551	0.2
273C	Olmitz loam, 5 to 9 percent slopes	391	0.1
T299	Minden silty clay loam, 0 to 2 percent slopes	588	0.2
T368	Macksburg silty clay loam, 0 to 2 percent slopes	1,690	0.5
T369	Winterset silty clay loam, 0 to 2 percent slopes	3,351	1.0
370	Sharpsburg silty clay loam, 0 to 2 percent slopes	263	0.1
370B	Sharpsburg silty clay loam, 2 to 5 percent slopes	15,330	4.5
370B2	Sharpsburg silty clay loam, 2 to 5 percent slopes, moderately eroded	1,520	0.4
370C	Sharpsburg silty clay loam, 5 to 9 percent slopes	11,489	3.4
370C2	Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	10,663	3.1
370D	Sharpsburg silty clay loam, 9 to 14 percent slopes	12,892	3.8
370D2	Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	23,215	6.8
T370B	Sharpsburg silty clay loam, 2 to 5 percent complex slopes	3,398	1.0
T370C	Sharpsburg silty clay loam, 5 to 9 percent complex slopes	575	0.1
692C2	Mayberry clay loam, 5 to 9 percent slopes, moderately eroded	530	0.1
692D	Mayberry clay loam, 9 to 14 percent slopes	974	0.3
692D2	Mayberry clay loam, 9 to 14 percent slopes, moderately eroded	2,254	0.7
715	Alluvial land, sandy	231	0.1
751C	Northboro silt loam, 5 to 9 percent slopes	408	0.1
751C2	Northboro silt loam, 5 to 9 percent slopes, moderately eroded	515	0.1
751D	Northboro silt loam, 9 to 14 percent slopes	534	0.1
751D2	Northboro silt loam, 9 to 14 percent slopes, moderately eroded	849	0.2
	Quarries and borrow areas	365	0.1
	Water	335	0.1
	Total	342,400	100.0

subangular blocky structure parting to weak fine granular; friable; common fine roots; slightly acid; gradual smooth boundary.

B1—14 to 18 inches; brown (7.5YR 4/4) heavy clay loam with very dark grayish brown (10YR 3/2) coats on ped faces; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B21t—18 to 26 inches; reddish brown (5YR 4/4) heavy clay loam that has few fine faint dark grayish brown (10YR 4/2) mottles; weak fine subangular blocky structure; firm; many thin discontinuous clay films on ped faces; medium acid; gradual smooth boundary.

B22t—26 to 34 inches; reddish brown (5YR 4/4) and brown (7.5YR 4/4) light silty clay and few fine faint grayish brown (10YR 5/2) mottles; weak fine subangular blocky structure; firm; many thin discontinuous clay films on ped faces; medium acid; gradual smooth boundary.

B23t—34 to 42 inches; strong brown (7.5YR 5/6) and grayish brown (2.5Y 5/2) light silty clay and few fine faint yellowish red (5YR 4/6) mottles; weak fine subangular blocky structure; firm; many thin discontinuous clay films on ped faces; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

B31t—42 to 50 inches; strong brown (7.5YR 5/6) and grayish brown (2.5Y 5/2) heavy clay loam with few fine faint yellowish red (5YR 5/6) mottles; weak fine subangular blocky structure; firm; many thin continuous clay films on ped faces; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

B32t—50 to 60 inches; yellowish brown (10YR 5/4) and grayish brown (2.5Y 5/2) heavy clay loam; weak fine subangular blocky structure; firm; many thin discontinuous clay films on ped faces; few black (10YR 2/1) soft bodies; slightly acid.

The solum is 40 to 65 inches thick. The A horizon is very dark gray (10YR 3/1), black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). It is clay loam or silty clay loam and is 10 to 20 inches thick. The B2 horizon has hue of 7.5YR or 5YR and value and chroma of 3/4, 4/4, 4/6, or 5/6. It has few to many mottles of dark grayish brown (10YR 4/2), grayish brown (2.5Y 5/2), yellowish red (5YR 4/8), and yellowish brown (10YR 5/6). It is 12 to 24 inches thick and is neutral to strongly acid. Some profiles have a C horizon that is clay loam or silty clay loam.

The eroded Adair soils are taxadjuncts to the Adair series; they lack mollic epipedons because of their thickness.

Adair soils are associated on the landscape with Marshall, Sharpsburg, and Shelby soils. They formed in parent material similar to that of Mayberry and Northboro soils. Unlike Marshall, Sharpsburg, and Shelby soils, Adair soils have a B2 horizon that has a reddish matrix or reddish mottles; they have a more clayey B2 horizon than that of Marshall, Sharpsburg, and Shelby soils. Adair soils have more coarse and medium sand and more unweathered mineral material in the B2 horizon than Mayberry soils. They have more coarse and medium sand and more clay in the B2 horizon than Northboro soils.

192C—Adair clay loam, 5 to 9 percent slopes. This soil is on lower side slopes and on points of ridgetops on uplands. The areas are typically 5 to 10 acres in size and are mostly long and narrow.

This soil has a profile similar to the one described as representative of the series, except that it has a slightly thicker surface layer.

Included with this soil in mapping are small areas of Mayberry and Shelby soils. Also included are soils that have a gray, clayey subsoil; these soils are shown on the soil maps by a symbol for gray clay.

This soil is moderately suited to row crops and well suited to hay and pasture. It is mostly farmed with adjacent soils. Erosion is the main hazard. Capability unit IIIe–2.

192C2—Adair clay loam, 5 to 9 percent slopes, moderately eroded. This soil is on side slopes and on points of narrow ridgetops on uplands. The areas are typically 5 to 10 acres in size and are long and narrow.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer. The surface layer is about 6 inches thick.

Included with this soil in mapping are small areas of Mayberry and Shelby soils. Also included are soils that have a gray, clayey subsoil; these soils are shown on the soil maps by a symbol for gray clay.

This soil is moderately suited to corn and soybeans and well suited to hay and pasture. Most areas are farmed with adjacent soils. Erosion is the main hazard. Capability unit IIIe–2.

192D—Adair clay loam, 9 to 14 percent slopes. This soil is on side slopes on uplands in long and narrow areas that are typically 5 to 20 acres in size.

This soil has the profile described as representative of the series. Included with this soil in mapping are small areas of Mayberry and Shelby soils. Also included are soils that have a gray, clayey subsoil; these soils are shown on the soil maps by a symbol for gray clay.

This soil is poorly suited to corn and soybeans and is well suited to hay and pasture. The larger areas are used for hay and pasture; most of the smaller areas are farmed with adjacent soils. Erosion is the main hazard. Capability unit IVe–2.

192D2—Adair clay loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes on uplands in long, narrow areas that are typically 5 to 20 acres in size.

This soil has a profile described as representative of the series, except that it has a thinner surface layer. The surface layer is about 6 inches thick.

Included with this soil in mapping are small areas of Mayberry and Shelby soils. Also included are soils that have a gray, clayey subsoil; these soils are shown on the soil maps by a symbol for gray clay.

This soil is poorly suited to corn and soybeans, but it is suited to hay and pasture. Most of the larger areas are used for hay and pasture, and many of the smaller areas are farmed with adjacent soils. Erosion is the main hazard. Capability unit IVe–2.

Alluvial land, sandy

715—Alluvial land, sandy. This mapping unit is on the flood plains along the larger streams and rivers. It is made up of sediment that has recently been deposited during floods. Most of the sediment is sand, but in some areas the sediment is a mixture of sand and silt. Areas of this mapping unit are typically 5 to 10 acres in size and are long and narrow. Included in mapping are small areas of Nodaway soils.

The native vegetation is mixed trees and grasses. The available water capacity is low, and the organic-matter content is low. Most areas are idle, but some are farmed with the adjacent soils. Flooding is the main hazard, and droughtiness is a limitation. Capability unit Vw–1.

Bremer series

The Bremer series consists of poorly drained soils on low stream benches along major streams and rivers. Bremer soils formed in moderately fine textured alluvium under native vegetation of tall prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam about 24 inches thick. The subsoil is very dark gray silty clay loam in the upper part; grayish brown silty clay loam with yellowish brown mottles in the middle part; and gray, dark gray, and light olive gray silty clay loam with yellowish brown mottles in the lower part. It is about 24 inches thick. The underlying material is light brownish gray silty clay loam that has yellowish brown iron stains.

Permeability is slow to moderately slow. The available water capacity is high, and the organic-matter content is 4 to 6 percent. The available phosphorus and potassium in the subsoil are low.

Bremer soils are well suited to row crops. They are used mainly for row crops, and in a few areas they are used for hay and pasture. Wetness is the main limitation.

Representative profile of Bremer silty clay loam, 0 to 2 percent slopes, in a cultivated field, 1,258 feet north and 66 feet west of the southeastern corner of sec. 4, T. 69 N., R. 39 W.

Ap—0 to 8 inches; black (10YR 2/1) light silty clay loam; weak fine granular structure; friable; medium acid; gradual smooth boundary.

A12—8 to 24 inches; black (10YR 2/1) light silty clay loam; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

B21t—24 to 32 inches; very dark gray (10YR 3/1) medium silty clay loam; few fine distinct yellowish red (5YR 5/6) iron stains; moderate fine subangular blocky structure; firm; thin discontinuous clay films on ped faces; neutral; gradual smooth boundary.

B22t—32 to 40 inches; grayish brown (2.5Y 5/2) heavy silty clay loam, dark gray (10YR 4/1) coatings on peds; few fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; thin discontinuous clay films on ped faces; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

B3tg—40 to 48 inches; mottled gray (10YR 5/1), dark gray (10YR 4/1), and light olive gray (5Y 6/2) medium silty clay loam with few fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; thin discontinuous clay films on ped faces; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

C—48 to 60 inches; light brownish gray (2.5Y 6/2) light silty clay loam that has few fine faint yellowish brown (10YR 5/6) iron stains; massive; friable; neutral.

The solum is 40 to 60 inches thick. The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1) silt loam or silty clay loam. It is 14 to 24 inches thick and is medium acid to neutral. The B horizon has hue of 10YR to 5Y, value of 3, 4, or 5, and chroma of 1 or 2; mottles have high and low chroma. This horizon is heavy or medium silty clay loam, and it is 14 to 24 inches thick. It is medium acid to neutral.

Bremer soils are associated on the landscape with Colo, Nevin, and Judson soils and formed in similar parent material. They are more clayey in the B horizon than Judson and Nevin soils, and they have a thinner A horizon and a more clayey solum than Colo soils.

43—Bremer silty clay loam, 0 to 2 percent slopes. This soil is on low stream benches along major streams and rivers. The areas are typically 10 to 20 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of Colo, Zook, and Wabash soils, and small areas of Bremer soils that have a silt loam surface layer.

This soil is well suited to row crops. Wetness is the main limitation. Capability unit IIw–1.

Colo series

The Colo series consists of poorly drained soils on flood plains and on the lower part of upland drainageways. Colo soils formed in noncalcareous, moderately fine textured sediment under native vegetation of prairie grasses. Slopes are 0 to 5 percent.

In a representative profile the surface layer is silty clay loam that is black in the upper part and black to very dark gray in the lower part. It is about 29 inches thick. The underlying material is silty clay loam that is black to very dark gray in the upper part and dark gray in the lower part.

Permeability is moderately slow, and the available water capacity is high. The available phosphorus and potassium in the subsoil are medium. The organic-matter content is 3 to 5 percent except in areas with silt loam overwash.

Colo soils are well suited to row crops and are used mainly for row crops. Wetness is the major limitation.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, in a cultivated field, 1,320 feet west and 1,250 feet north of the southeastern corner of sec. 21, T. 70 N., R. 36 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam; weak fine subangular blocky structure parting to weak granular; friable; neutral; gradual smooth boundary.

A12—8 to 19 inches; black (N2/0) silty clay loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13—19 to 29 inches; black (10YR 2/1) to very dark gray (10YR 3/1) silty clay loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

AC—29 to 54 inches; black (10YR 2/1) to very dark gray (10YR 3/1) heavy silty clay loam; weak fine prismatic structure parting to moderate fine subangular blocky; friable; neutral; gradual smooth boundary.

Cg—54 to 60 inches; dark gray (10YR 4/1) heavy silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; firm; neutral.

The solum is 28 to 54 inches thick. The A horizon has hue that is neutral or 10YR, value of 2 or 3, and chroma of 1 or 0. It is slightly acid or neutral. The upper part of the A horizon ranges from silty clay loam to silt loam. The C horizon has hue of 10YR, value of 2, 3, or 4, and chroma of 1 or 0.

Colo soils are associated on the landscape with Judson, Kennebec, Nodaway, Zook, and Wabash soils. They formed in parent material similar to that of Judson, Kennebec, Nodaway, and Bremer soils. Colo soils are more clayey in the 10- to 40-inch section than Judson and Kennebec soils and the lighter colored Nodaway soils. They are less clayey in the profile than Wabash and Zook soils, and they have a thicker A horizon and are less clayey than Bremer soils.

133—Colo silty clay loam, 0 to 2 percent slopes. This soil is on flood plains, low benches, and alluvial fans. The areas are typically 10 to 40 acres in size and are irregular in shape.

This soil has the profile described as representative of the series. The content of organic matter in the plow layer is 3 to 5 percent.

Included with this soil in mapping are small areas of Kennebec, Wabash, and Zook soils and an area of soils in depressions on a bench in the northwestern quarter of sec. 6, T. 67 N., R. 36 W. This area is included because the drainage is similar to that in areas of Colo soils.

This soil is well suited to row crops and is used mostly for row crops. Wetness is the main limitation. Capability unit IIw-1.

133+—Colo silt loam, overwash, 0 to 2 percent slopes. This soil is on flood plains and alluvial fans where flooding and siltation are more frequent than in areas of other Colo soils. The areas are typically 10 to 40 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that 6 to 15 inches of dark grayish brown or very dark grayish brown silty material overlies the original black surface layer. The content of organic matter in the plow layer is 2 to 3 percent.

Included with this soil in mapping are small areas of Kennebec, Wabash, and Zook soils.

This soil is well suited to row crops and is used mainly for row crops. Wetness is the main limitation. This soil generally is somewhat easier to till than Colo silty clay loam. Capability unit IIw-1.

11B—Colo-Judson silty clay loams, 2 to 5 percent slopes. This complex is on small stream bottoms and on alluvial fans and foot slopes adjacent to the bottom lands. The areas vary in size and are irregular in shape. It is about 65 percent Colo soils and 35 percent Judson soils. Judson soils are better drained and have coarser textures than Colo soils.

The soils in this complex have a profile that is similar to that described as representative of their series. The surface layer is mainly silty clay loam.

Included with this complex in mapping are some areas with a silt loam surface layer and small areas of Kennebec, Nodaway, Olmitz, and Zook soils.

This complex is well suited to row crops. It is used mostly for row crops, and in some areas it is used for hay and pasture (fig. 7). Wetness is the main limitation. Capability unit IIw-1.

Gara series

The Gara series consists of moderately well drained and well drained soils on side slopes and low ridgetops on uplands. Gara soils formed in glacial till under native vegetation of mixed grasses and trees. Slopes are 9 to 40 percent.

In a representative profile the surface layer is very dark gray loam about 7 inches thick. The subsurface layer is dark grayish brown loam about 5 inches thick. The subsoil extends to a depth of 46 inches. It is brown clay loam in the upper part and dark yellowish brown clay loam with yellowish brown and light olive gray mottles in the middle part. The lower part of the

Figure 7.—A newly seeded grassed waterway on Colo-Judson soils.

subsoil and the underlying material are yellowish brown and light olive gray clay loam.

Permeability is moderately slow, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is very low. The organic-matter content is 1 to 4 percent.

Gara soils are used mostly as woodland pasture. Erosion is the main hazard.

Representative profile of Gara loam, 9 to 14 percent slopes, in woodland, 5 feet south and 12 feet east of the northeastern corner of sec. 35, T. 68 N., R. 37 W.

A1—0 to 7 inches; very dark gray (10YR 3/1) loam; weak fine granular structure; friable; common fine roots; slightly acid; gradual smooth boundary.

A2—7 to 12 inches; dark grayish brown (10YR 4/2) loam; weak thin platy structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.

B1—12 to 21 inches; brown (10YR 4/3) light clay loam; few fine faint silt coatings on ped faces, light brownish gray (10YR 6/2) when dry; moderate medium subangular blocky structure; friable; strongly acid; gradual smooth boundary.

B21t—21 to 30 inches; dark yellowish brown (10YR 4/4) medium clay loam; few fine faint silt coatings on ped faces, light grayish brown (10YR 6/2) when dry; moderate medium subangular blocky structure; firm; thin continuous clay film on ped faces; few fine black (10YR 2/1) soft bodies; strongly acid; gradual smooth boundary.

B22t—30 to 40 inches; dark yellowish brown (10YR 4/4) medium clay loam; few fine faint yellowish brown (10YR 5/6) and few fine distinct light olive gray (5Y 6/2) mottles; moderate medium subangular blocky structure; firm; thin continuous clay films on ped faces; few fine black (10YR 2/1) soft bodies; strongly acid; gradual smooth boundary.

B3t—40 to 46 inches; yellowish brown (10Y 5/4 to 5/6) and light olive gray (5Y 6/2) medium clay loam; fine medium subangular blocky structure with tendency towards vertical cleavage; firm; thin continuous clay films; few medium reddish brown (5YR 4/4) soft bodies; strongly acid; gradual smooth boundary.

C—46 to 60 inches; yellowish brown (10YR 5/4 to 5/6) and light olive gray (5Y 6/2) light clay loam; massive; firm; strongly acid.

Typically, the solum is 40 to 48 inches thick, but it ranges from 36 to 70 inches. The A1 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). It is silt loam or loam and is 6 to 10 inches thick. The A2 horizon is loam or silt loam and is 4 to 8 inches thick. Some peds have a color value of 3, but when dry they have value of 6. Silt coatings are common. The B2t horizon predominately has hue of 10YR, but in places the hue is 7.5YR. This horizon has value of 4 or 5 and chroma of 3 or 4. It is 16 to 34 inches thick. There are clay films and silt coatings in parts of the B horizon. Carbonate concretions are in the B3 horizon in some places.

Gara soils are associated on the landscape with Ladoga and Shelby soils; they formed in parent material similar to that of Shelby soils. They are downslope from and are more sandy than Ladoga soils. Gara soils are in positions on the landscape similar to those of Shelby soils, but they have a thinner A1 or Ap horizon. Unlike Shelby soils, Gara soils have an A2 horizon.

179D—Gara loam, 9 to 14 percent slopes. This soil is on side slopes and low ridgetops on uplands. Areas are typically 10 to 30 acres in size and irregular in shape.

This soil has the profile described as representative of the series. The plow layer is 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of Shelby soils and some Gara soils that have a silt loam surface layer.

This soil is poorly suited to row crops and well suited to hay and pasture. In most areas it has been cleared and is used for pasture. Erosion is the main hazard. Capability unit IVe–1.

179D2—Gara loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes and low ridgetops on uplands. The areas are typically 10 to 30 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer that is loam or light clay loam about 7 inches thick. In cultivated areas some subsoil has been mixed with the surface layer. There is no subsurface layer in most places, and the plow layer rests directly on the firm, dense subsoil. The plow layer is 1 to 3 percent organic matter.

Included with this soil in mapping are small areas of Shelby soils and small areas of Gara soils that have a silt loam surface layer.

This soil is poorly suited to row crops and well suited to hay and pasture. Most areas have been cleared and are used for pasture. Fertility is a more limiting factor for this soil than for the uneroded Gara soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded representative soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. This moderately eroded soil crusts after heavy rain, making seedling emergence difficult. Returning crop residue to the soil and adding manure are necessary to maintain tilth and crop production. Fertilization and erosion control are more important on this soil than on the uneroded soils. Removing the topsoil causes severe management problems because of unfavorable subsoil properties. Capability unit IVe–1.

179E2—Gara loam, 14 to 18 percent slopes, moderately eroded. This soil is on side slopes on uplands in areas that are typically 5 to 25 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer and a less distinct subsurface layer. The surface layer is about 5 inches thick.

Included with this soil in mapping are small areas of Shelby soils and small areas of Gara soils that have a silt loam surface layer.

This soil generally is not suited to row crops but is suited to hay and pasture. Most areas are wooded and are used as pasture. Erosion is the main hazard. Capability unit VIe–1.

179F2—Gara loam, 18 to 25 percent slopes, moderately eroded. This soil is on side slopes on uplands in areas that are typically 10 to 30 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer. The surface layer is about 4 inches thick, and the subsurface layer is less distinct.

Included with this soil in mapping are small areas of Shelby soils. Also included are small areas of a soil similar to Gara soils, except that the profile is calcareous at a shallower depth.

This soil is not suited to row crops; it is well suited to pasture. Most areas are wooded and are used as pasture. Erosion is the main hazard. Capability unit VIIe–1.

179G2—Gara loam, 25 to 40 percent slopes, moderately eroded. This soil is on side slopes on uplands in areas that are typically 10 to 30 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer and the subsurface layer is less distinct. The surface layer is about 4 inches thick.

Included with this soil in mapping are small areas of Shelby soils and small areas of a soil similar to Gara soils, except that the profile is calcareous at a shallower depth.

This soil is not suited to row crops; it is well suited to pasture. Most areas are wooded and are used as pasture. Erosion is the main hazard. Capability unit VIIe–1.

Judson series

The Judson series consists of well drained or moderately well drained soils on alluvial fans and foot slopes. Judson soils formed in noncalcareous, moderately fine textured sediment under a native vegetation of prairie grasses. Slopes are 2 to 5 percent.

In a representative profile the surface layer is very dark brown in the upper part and very dark grayish brown in the middle and lower parts. It is light silty clay loam about 33 inches thick. The subsoil extends to a depth of 60 inches. It is light silty clay loam that is dark brown in the upper part and brown in the lower part.

Permeability is moderate, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is low. The organic-matter content is 4 to 6 percent.

Judson soils are well suited to row crops and are used for row crops. Erosion is the main hazard.

Representative profile of Judson silty clay loam, 2 to 5 percent slopes, in a cultivated field, 1,294 feet south and 669 feet west of the northeastern corner of sec. 28, T. 70 N., R. 39 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) light silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

A12—7 to 14 inches; very dark brown (10YR 2/2) light silty clay loam; very dark grayish brown (10YR 3/2) crushed; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

A13—14 to 24 inches; very dark grayish brown (10YR 3/2) light silty clay loam; weak fine granular structure; friable; neutral; gradual smooth boundary.

A3—24 to 33 inches; very dark grayish brown (10YR 3/2) light silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; gradual smooth boundary.

B2—33 to 42 inches; dark brown (10YR 3/3) light silty clay loam; moderate fine subangular blocky structure; friable; few very dark grayish brown (10YR 3/2) coatings on ped faces; slightly acid; gradual smooth boundary.

B3—42 to 60 inches; brown (10YR 4/3) light silty clay loam; moderate fine subangular blocky structure; friable; few dark grayish brown (10YR 4/2) coatings on ped faces; neutral.

The solum is 40 to 60 inches thick. The A horizon is light silty clay loam or silt loam. It is 20 to 36 inches thick and is neutral or slightly acid. The B horizon is 24 to 40 inches thick.

Judson soils are associated on the landscape with Colo, Kennebec, and Nodaway soils, and they formed in similar parent material. Judson soils are less clayey throughout the profile than Colo soils. They have chroma of 2 or less, which does not extend to so great a depth as in Kennebec soils. Judson soils have a darker colored, thicker A horizon than Nodaway soils, and they do not have stratification like Nodaway soils.

8B—Judson silty clay loam, 2 to 5 percent slopes. This soil is on foot slopes and alluvial fans adjacent to bottom lands. The areas are typically 10 to 20 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of Kennebec and Olmitz soils and small areas of Judson soils that have a silt loam surface layer.

This soil is well suited to row crops and is mostly used for row crops. Some areas are used for pasture or hay. Erosion is the main hazard. Capability unit IIe–1.

Kennebec series

The Kennebec series consists of moderately well drained soils on flood plains along major streams. These soils formed in medium textured and moderately fine textured sediment under native vegetation of tall prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is very dark brown in the upper part and black in the lower part. It is silt loam about 36 inches thick. The layer below that is black silt loam about 9 inches thick. The underlying material is very dark gray light silty clay loam.

Permeability is moderate, and the available water capacity is high. In the subsoil the content of available phosphorus is low and that of available potassium is very low. The organic-matter content is 4 to 6 percent.

Kennebec soils are mainly used for crops. These soils have no major limitations that affect their use for crops, although some low-lying areas are subject to infrequent flooding.

Representative profile of Kennebec silt loam, 0 to 2 percent slopes, in a cultivated field, 1,000 feet east and 700 feet south of the northwestern corner of sec. 20, T. 69 N., R. 39 W.

Ap—0 to 9 inches; very dark brown (10YR 2/2) silt loam; moderate medium to fine granular structure; friable; medium acid; clear smooth boundary.

A12—9 to 18 inches; black (10YR 2/1) silt loam; moderate medium granular structure; friable; slightly acid; diffuse smooth boundary.

A13—18 to 36 inches; black (10YR 2/1) silt loam; weak fine subangular blocky structure; friable; slightly acid; diffuse smooth boundary.

AC—36 to 45 inches; black (10YR 2/1) silt loam; very dark brown (10YR 2/2) when rubbed; weak fine to medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

C—45 to 63 inches; very dark gray (10YR 3/1) light silty clay loam; moderate medium subangular blocky structure; friable; light brownish gray (10YR 6/2) silt coatings on ped faces; slightly acid.

Kennebec soils have a solum that is more than 36 inches thick. The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). It is silt loam or light silty clay loam and is 27 to 45 inches thick. The C horizon is black (10YR 2/1), very dark gray (10YR 3/0), or very dark grayish brown (10YR 3/2) silt loam or light silty clay loam. This horizon is slightly acid or neutral.

Kennebec soils are associated on the landscape with Colo, Judson, and Nodaway soils, and they formed in similar parent material. Kennebec soils are less clayey throughout the profile than Colo soils. They lack the stratification of Nodaway soils and have a thicker, darker colored A horizon. Unlike Judson soils, Kennebec soils do not have a chroma of 3 above 36 inches.

212—Kennebec silt loam, 0 to 2 percent slopes. This soil is on flood plains on bottom lands in areas that are typically 10 to 40 acres in size and irregular in shape.

Included with this soil in mapping are small areas of Colo, Judson, and Nodaway soils.

This soil is well suited to row crops and is mostly used for row crops. It has no limitation to use for crops. Capability unit I–3.

Ladoga series

The Ladoga series consists of moderately well drained soils on convex ridgetops and side slopes. Ladoga soils formed in loess under native vegetation of mixed grasses and trees. Slopes are 2 to 14 percent.

In a representative profile the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsurface layer is dark grayish brown silt loam about 4 inches thick. The subsoil extends to a depth of 48 inches. It is brown silty clay loam in the upper part, brown heavy silty clay loam and silty clay with light brownish gray and strong brown mottles in the middle part, and light brownish gray and strong brown silty clay loam in the lower part. The underlying material is light brownish gray and strong brown silty clay loam.

Permeability is moderately slow, and the available water capacity is high. In the subsoil, the content of available phosphorus is medium and that of available potassium is very low. The organic-matter content is 1 to 4 percent.

Ladoga soils are used mainly for pasture and as woodland. Many of the less sloping areas have been cleared and are used for cultivated crops. Erosion is the main hazard.

Representative profile of Ladoga silt loam, 2 to 5 percent slopes, in oak-hickory timber, 2,500 feet east and 10 feet south of the northwestern corner of sec. 21, T. 70 N., R. 36 W.

A1—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak fine granular structure; friable; many fine roots; neutral; gradual smooth boundary.

A2—7 to 11 inches; dark grayish brown (10YR 4/2) silt loam; weak thin platy structure parting to weak fine granular; friable; common fine roots; slightly acid; clear smooth boundary.

B1—11 to 15 inches; brown (10YR 4/3) light silty clay loam; dark brown (10YR 3/3) coatings on ped faces; moderate fine subangular blocky structure; friable; few discontinuous silt coatings on ped faces; medium acid; gradual smooth boundary.

B21t—15 to 26 inches; brown (10YR 4/3) light silty clay; strong fine subangular blocky structure; friable; few discontinuous silt coatings on ped faces; thin discontinuous clay films on ped faces and root channels; strongly acid; gradual smooth boundary.

B22t—26 to 35 inches; brown (10YR 4/3) heavy silty clay loam; many fine distinct light brownish gray (10YR 6/2) mottles and few fine faint strong brown (7.5YR 5/6) mottles; moderate fine subangular blocky structure; friable; thin discontinuous clay films on ped faces and root channels; common black (10YR 2/1) soft bodies; strongly acid; gradual smooth boundary.

B3t—35 to 48 inches; light brownish gray (2.5Y 6/2) and strong brown (7.5YR 5/6) medium silty clay loam; moderate fine subangular blocky structure; friable; thin discontinuous clay films on ped faces and root channels; medium acid;

common black (10YR 2/1) soft bodies; gradual smooth boundary.

C—48 to 60 inches; light brownish gray (2.5Y 6/2) and strong brown (7.5YR 5/6) medium silty clay loam; massive with vertical cleavage; friable; common black (10YR 2/1) soft bodies; medium acid.

The solum is 48 to 60 inches thick. The A1 horizon is black (10YR 2/1), very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). It is 6 to 10 inches thick. The A2 horizon is 2 to 6 inches thick. The B2 horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4). It ranges from medium silty clay loam to light silty clay. Silt coatings are evident in the upper part of the horizon and mottles increase with depth. The B horizon is 32 to 50 inches thick.

Eroded Ladoga soils are taxadjuncts to the Ladoga series because they have a surface horizon that has a color value of 4 or higher if mixed to a depth of 7 inches.

Ladoga soils are associated on the landscape with Gara and Sharpsburg soils and formed in parent material similar to that of Marshall and Sharpsburg soils. Ladoga soils are less sandy than Gara soils, and they have a thinner A1 horizon than Marshall and Sharpsburg soils, which do not have an A2 horizon.

76B—Ladoga silt loam, 2 to 5 percent slopes. This soil is on ridgetops on uplands. The areas are typically 5 to 20 acres in size and are long and narrow.

This soil has the profile described as representative of the series. The plow layer has 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils.

This soil is well suited to row crops. Most areas have been cleared and are used for row crops. Erosion is the main hazard. Capability unit IIe–1.

76C—Ladoga silt loam, 5 to 9 percent slopes. This soil is on lower ridgetops on uplands. The areas are typically 5 to 10 acres in size and are long and narrow.

This soil has a profile similar to the one described as representative of the series, except that the subsurface layer is less distinct. The plow layer is 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas are wooded. Erosion is the main hazard. Capability unit IIIe–1.

76C2—Ladoga silt loam, 5 to 9 percent slopes, moderately eroded. This soil is on lower ridgetops on uplands. Areas are long and narrow and are typically 5 to 10 acres in size.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer that is silty clay loam in some places and is 7 inches thick. In cultivated areas some subsoil has been mixed with the surface layer. There is no subsurface layer in most places. The content of organic matter in the plow layer is 1 to 2 percent.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas have been cleared and are used for row crops or pasture, but some areas are still wooded. Fertility is a more limiting factor for this soil than for the uneroded Ladoga soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. This soil requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. After heavy rains this moderately eroded soil crusts, making seedling emergence difficult. Returning crop residue to the surface and adding manure are necessary to maintain tilth and crop production. Management of pastures requires greater input of fertilizer and erosion control than on the uneroded soil. Capability unit IIIe–1.

76D—Ladoga silt loam, 9 to 14 percent slopes. This soil is on side slopes on the uplands in areas that are typically 10 to 20 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series except that the subsurface layer is less distinct. The plow layer is 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas are wooded and are used for pasture. Erosion is the main hazard. Capability unit IIIe–1.

76D2—Ladoga silt loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes on uplands. Areas are typically irregular in shape and 10 to 30 acres in size.

This soil has a plow layer that is silty clay loam in some places and is 7 inches thick. In cultivated areas, some subsoil has been mixed with the surface layer. In most places there is no subsurface layer. The content of organic matter in the plow layer is 1 to 2 percent.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas have been cleared and are used for row crops or pasture, but some are still wooded. Fertility is a more limiting factor for this soil than for the uneroded Ladoga soil. This soil also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. After heavy rains this moderately eroded soil crusts, and seedling emergence is difficult. Returning crop residue to the surface and adding manure are necessary to maintain tilth and crop production. Management of pastures requires greater input of fertilizer and erosion control than on the uneroded soil. Capability unit IIIe–1.

Macksburg series

The Macksburg series consists of somewhat poorly drained soils on high stream benches near the Nodaway and East Nodaway Rivers. Macksburg soils formed in loess under native vegetation of tall prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black light silty clay loam in the upper part and very dark brown silty clay loam in the lower part. It is about 20 inches thick. The subsoil extends to a depth of 48 inches. It is very dark grayish brown medium silty clay loam in the upper part; dark grayish brown, brown, and grayish brown light silty clay and heavy silty clay loam with yellowish brown mottles in the middle part; and olive gray medium silty clay loam with yellowish brown mottles in the lower part. The underlying material is light olive gray light silty clay loam with strong brown mottles.

Permeability is moderately slow, and the available water capacity is high. In the subsoil, the content of available phosphorus is low and that of available potassium is medium. The organic-matter content is 4 to 6 percent.

Macksburg soils are used mainly for row crops. There are no serious limitations or hazards to their use for crops.

Representative profile of Macksburg silty clay loam, 0 to 2 percent slopes, in a cultivated field, 90 feet west and 640 feet north of the southeastern corner of sec. 13, T. 68 N., R. 37 W.

Ap—0 to 8 inches; black (10YR 2/1) light silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; medium acid; gradual smooth boundary.

A12—8 to 14 inches; black (10YR 2/1) light silty clay loam; weak fine subangular blocky structure parting to moderate medium granular; friable; medium acid; gradual smooth boundary.

A13—14 to 20 inches; very dark brown (10YR 2/2) medium silty clay loam; weak very fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B1—20 to 24 inches; very dark grayish brown (10YR 3/2) medium silty clay loam; moderate, very fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B21t—24 to 33 inches; dark grayish brown (10YR 4/2) and brown (10YR 5/3) heavy silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; moderate fine subangular blocky structure; firm; thin discontinuous clay films on ped faces; few fine black (10YR 2/1) bodies; slightly acid; gradual smooth boundary.

B22t—33 to 39 inches; grayish brown (10YR 2.5Y 5/2) light silty clay; common fine distinct yellowish brown (10YR 5/6) mottles; moderate medium fine subangular blocky structure; firm; thin discontinuous clay films on ped faces; few fine black (10YR 2/1) bodies on ped faces; slightly acid; gradual smooth boundary.

B3—39 to 48 inches; olive gray (5Y 5/2) medium silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure parting to weak medium coarse subangular blocky; friable; few fine black (10YR 2/1) light silty clay loam with strong brown (7.5YR 5/6) mottles; massive; friable; few fine black (10YR 2/1) bodies; neutral; gradual smooth boundary.

C—48 to 60 inches; light olive gray (5Y 5/2) light silty clay loam; strong brown (7.5YR 5/6) mottles; massive; friable; few fine black (10YR 2/1) bodies; neutral.

The solum is 48 to 84 inches thick. The A horizon is black (10YR 2/1) or very dark brown (10YR 2/2). It is light silty clay loam or heavy silt loam and is 16 to 24 inches thick. The A3 and B1 horizons are commonly very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2). The upper part of the B2 horizon is typically dark grayish brown (10YR 4/2), but a small part of the matrix is brown (10YR 4/3 or 5/3), dark yellowish brown (10YR 4/4), or olive brown (2.5Y 4/4). The lower part is dark grayish brown (2.5Y 4/2), grayish brown (2.5Y 5/2), or olive gray (5Y 4/2 or 5/2). High chroma mottles are in the upper and lower parts of the B2 horizon, and low chroma mottles are in the lower part in some places. The B2t horizon is heavy silty clay loam or light silty clay and has a clay content between 36 and 42 percent. Clay films are evident on ped faces and root channels in the B2t horizon.

Macksburg soils are associated on the landscape with Sharpsburg and Winterset soils. They formed in parent material similar to that of Ladoga, Marshall, Minden, Sharpsburg, and Winterset soils. In the upper part of the B2 horizon, Macksburg soils have lower chroma than Sharpsburg soils and higher chroma than Winterset soils. They have a thicker A horizon than that of Ladoga soils, and unlike Ladoga soils, they do not have an A2 horizon. Macksburg soils have a thicker A horizon than Marshall soils and are more clayey in the B2 horizon than Marshall and Minden soils.

T368—Macksburg silty clay loam, 0 to 2 percent slopes. This soil is on broad, high stream benches near the East Nodaway and Nodaway Rivers. The areas are typically 10 to 30 acres in size and irregular in shape.

This soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till.

Included with this soil in mapping are small areas of Sharpsburg soils.

This soil is well suited to row crops and is used for row crops. It has no serious limitations or hazards to use for crops. This soil has low potential for landfill and sewage lagoon sites because of the danger of ground water pollution. Capability unit I–2.

Marshall series

The Marshall series consists of well drained soils on ridgetops and side slopes on uplands and on stream benches near the Nishnabotna River. Marshall soils formed in Wisconsin loess under native vegetation of prairie grasses. Slopes are 2 to 14 percent on the uplands and 0 to 5 percent on benches.

In a representative profile the surface layer is very dark brown silty clay loam about 15 inches thick. The subsoil extends to a depth of 48 inches. It is silty clay loam and is dark brown in the upper part and brown with light gray, grayish brown, and yellowish brown mottles in the lower part. The substratum is light brownish gray silty clay loam with brown mottles.

Permeability is moderate, and the available water capacity is high. The subsoil is low in available phosphorus and potassium. The organic-matter content is 2 to 4 percent in uneroded areas.

Marshall soils on ridgetops and benches are used mainly for row crops and nursery crops, and Marshall soils on side slopes are used for row crops, small grain, hay, and pasture crops. Erosion is the major hazard.

Representative profile of Marshall silty clay loam, 2 to 5 percent slopes, in a cultivated field, 1,420 feet south and 1,260 feet east of the northwestern corner of sec. 10, T. 68 N., R. 39 W.

Ap—0 to 6 inches; very dark brown (10YR 2/2) light silty clay loam; dark grayish brown (10YR 4/2) dry; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

A12—6 to 15 inches; very dark brown (10YR 2/2) light silty clay loam; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

B1—15 to 28 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coating on peds; weak fine subangular blocky structure parting to weak fine granular; friable; medium acid; gradual smooth boundary.

B21—28 to 36 inches; brown (10YR 4/3) medium silty clay loam; weak fine subangular blocky structure; friable; few iron stains on ped faces; strongly acid; gradual smooth boundary.

B22—36 to 42 inches; brown (10YR 4/3) medium silty clay loam; few fine faint light gray (10YR 6/1) and few fine distinct brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B3—42 to 48 inches; brown (10YR 4/4) light silty clay loam; many fine distinct grayish brown (10YR 5/2) and few fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; few black (10YR 2/1) soft bodies; slightly acid; gradual smooth boundary.

C—48 to 60 inches; light brownish gray (2.5Y 6/2) light silty clay loam; common medium distinct brown (7.5YR 4/4) mottles; massive; tendency toward vertical cleavage; friable; common black (10YR 2/1) soft bodies; slightly acid.

Typically, the solum is more than 40 inches thick. The A horizon is black (10YR 2/1) or very dark brown (10YR 2/2) heavy silt loam or light silty clay loam. It is 7 to 18 inches thick, except on the benches, where it is slightly thicker. The B2 horizon has dominant colors in the hue of 10YR, value of 3 to 5, and chroma of 3 or 4. It is light or medium silty clay loam and is 12 to 20 inches thick. The average clay content of the B horizon ranges from 27 to 35 percent.

Marshall soils that have gray mottles at a depth of less than 26 inches and that have many gray mottles within a depth of less than 40 inches are taxadjuncts to the Marshall series. In addition, the eroded Marshall silty clay loam, mottled subsoil, is a taxadjunct to the series because it lacks the mollic epipedon characteristic of thicker Marshall soils.

Marshall soils are associated on the landscape with Adair and Shelby soils. They formed in parent material similar to that of Sharpsburg and Ladoga soils. They are less sandy than the till-derived Adair and Shelby soils and lack the reddish colors that occur in the B horizon of the Adair soils. Unlike Ladoga soils, Marshall soils have no A2 horizon and have less distinct structure in the B horizon. Marshall soils are less clayey in the B horizon than Sharpsburg soils.

T9—Marshall silty clay loam, 0 to 2 percent slopes. This soil is on broad, high stream benches near the Nishnabotna River. The areas are typically 5 to more than 100 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a slightly thicker surface layer that is about 20 inches thick. The soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till.

Included with this soil in mapping are small areas of Minden soils.

This soil is well suited to row crops and is mostly used for row crops. In some areas it is well suited to and is used for growing nursery stock. This soil has no limitations to use for row crops. It has low potential for landfills and sewage lagoons because of the danger of ground-water pollution. Capability unit I–1.

9B—Marshall silty clay loam, 2 to 5 percent slopes. This soil is on ridges on uplands. The areas are typically 20 to 40 acres in size and are irregular in shape.

This soil has the profile described as representative of the series. The content of organic matter in the plow layer is 3 to 4 percent.

This soil is well suited to row crops, and is used mostly for row crops. Erosion is the main hazard. Capability unit IIe–1.

9B2—Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded. This soil is on ridgetops on uplands. The areas are typically 5 to 10 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer that is very dark grayish brown silty clay loam about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills.

This soil is well suited to row crops, and in most areas it is used for row crops. Fertility is a more limiting factor for this soil than for the uneroded Marshall soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than for the uneroded soil. This soil also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Capability unit IIe–1.

9C—Marshall silty clay loam, 5 to 9 percent slopes. This soil is on narrow secondary ridgetops and on side slopes on uplands. The areas are typically 5 to 30 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a slightly thinner surface layer, which is about 12 inches thick. The content of organic matter in the plow layer is 3 to 4 percent.

Included with this soil in mapping are small areas of Northboro soils and Marshall soils that have a mottled subsoil.

This soil is moderately suited to row crops and well suited to hay and pasture crops. Most areas are used for row crops, but some are used for hay and pasture. Erosion is the main hazard. Capability unit IIIe–1.

9C2—Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded. This soil is on narrow secondary ridgetops and side slopes on uplands. The areas are typically 5 to 30 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer that is very dark grayish brown silty clay loam about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains on sidehills.

Included with this soil in mapping are small areas of Northboro soils and Marshall soils that have a mottled subsoil.

This soil is moderately suited to row crops, and in most areas it is used for row crops. It is well suited to hay and pasture, and in some areas it is used for hay and pasture. Fertility is a more limiting factor for this soil than for the uneroded Marshall soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. This soil requires a higher level of management and is more erodible. Erosion from runoff is the main hazard (fig. 8). Capability unit IIIe–1.

T9B—Marshall silty clay loam, 2 to 5 percent complex slopes. This soil is on broad, high stream benches near the Nishnabotna River. The areas are typically 5 to 60 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a slightly thicker surface layer about 18 inches thick. This soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till.

Included with this soil in mapping are small areas of Minden soils.

This soil is well suited to row crops and is mostly used for row crops. Conservation practices are difficult because of the short, irregular slopes. This soil is well suited to and is used for growing nursery stock. It has low potential for landfills and sewage lagoons because there is a danger of ground-water pollution. Erosion is the main hazard. Capability unit IIe–1.

99C—Marshall silty clay loam, mottled subsoil, 5 to 9 percent slopes. This soil is on narrow secondary ridgetops and on side slopes on uplands. The areas are typically 5 to 20 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has many gray mottles in the subsoil. The content of organic matter in the plow layer is 3 to 4 percent.

Included with this soil in mapping are small areas of Northboro soils and other Marshall soils. Also in-

Figure 8.—**Grassed backslope terraces on Marshall soils are parallel and have tile outlets.**

cluded are some small areas of grayish silt loam, which are indicated on the soil map by spot symbols.

This soil is moderately suited to row crops, and in most areas it is used for row crops. It is well suited to hay and pasture, and in some areas it is used for this purpose. Erosion is the main hazard. Capability unit IIIe-1.

99C2—Marshall silty clay loam, mottled subsoil, 5 to 9 percent slopes, moderately eroded. This soil is on narrow ridgetops and on side slopes on uplands. The areas are typically 5 to 20 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has many gray mottles in the subsoil. It has a plow layer that is very dark grayish brown silty clay loam about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Northboro soils and other Marshall soils. Also included are small areas of grayish silt loam, which are indicated on the soil map by spot symbols.

This soil is moderately suited to row crops and in most areas it is used for row crops. It is well suited to hay and pasture, and in some areas it is used for hay and pasture. Fertility is a more limiting factor for this soil than for the uneroded Marshall soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Capability unit IIIe-1.

99D—Marshall silty clay loam, mottled subsoil, 9 to 14 percent slopes. This soil is on side slopes on uplands. The areas are typically 5 to 40 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has grayish mottles in the subsoil and has a thinner surface layer about 8 inches thick. The content of organic matter in the plow layer is 3 to 4 percent.

Included with this soil in mapping are small areas of Adair, other Marshall, and Shelby soils.

This soil is moderately suited to row crops and is well suited to hay and pasture crops. Most areas are used for row crops and hay and pasture crops. Erosion is the main hazard. Capability unit IIIe-1.

99D2—Marshall silty clay loam, mottled subsoil, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes on uplands in areas that are typically 15 to 40 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has grayish mottles in the subsoil. It has a plow layer that is very dark grayish brown silty clay loam about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Adair, other Marshall, and Shelby soils.

This soil is moderately suited to row crops and well suited to hay and pasture. In most areas it is used for row crops and hay and pasture. Fertility is a more limiting factor for this soil than for the uneroded Marshall soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Capability unit IIIe-1.

Mayberry series

The Mayberry series consists of somewhat poorly drained soils on low nose slopes and convex side slopes on uplands. Mayberry soils formed in sediment from glacial till that weathered under native vegetation of prairie grasses. Slopes are 5 to 14 percent.

In a representative profile the surface layer is very dark grayish brown clay loam about 10 inches thick. The subsoil extends to a depth of 60 inches. It is brown silty clay mottled with reddish brown in the upper part; mottled brown, strong brown, and reddish brown silty clay in the middle part; and grayish brown silty clay loam with reddish brown mottles in the lower part.

Permeability is slow, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is very low. The organic-matter content is 2 to 4 percent.

Mayberry soils are used primarily for hay or pasture. Erosion is the main hazard.

Representative profile of Mayberry clay loam, 9 to 14 percent slopes, in pasture, 990 feet south and 60 feet west of the northeastern corner of sec. 20, T. 67 N., R. 37 W.

A1—0 to 10 inches; very dark grayish brown (10YR 3/2) clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; medium acid; gradual smooth boundary.

B21t—10 to 20 inches; brown (7.5YR 4/2) silty clay; many fine distinct reddish brown (2.5YR 4/4) mottles; moderate medium subangular blocky structure; firm; thin continuous clay films on ped faces and root channels; few black (10YR 2/1) soft bodies; slightly acid; gradual smooth boundary.

B22t—20 to 31 inches; mottled brown (7.5YR 4/2, 4/4), strong brown (7.5YR 5/6), and reddish brown (2.5YR 4/4) silty clay; moderate medium subangular blocky structure; firm; thin continuous clay films on ped faces and root channels; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

B23—31 to 46 inches; brown (7.5YR 4/4) silty clay; common medium distinct grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) mottles and few fine distinct yellowish red (5YR 4/6) mottles; weak fine subangular blocky structure; firm; few black (10YR 2/1) soft bodies; increasing sand size; mildly alkaline; gradual smooth boundary.

B3—46 to 60 inches; grayish brown (2.5Y 6/2) silty clay loam; many medium distinct reddish brown (5YR 4/4) mottles; weak fine subangular blocky structure; firm; few black (10YR 2/1) soft bodies; increasing sand size; few scattered pebbles; mildly alkaline.

The solum is 40 to 85 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2. It is clay loam or silty clay loam and is 10 to 15 inches thick. This horizon is medium or slightly acid. The B2t horizon has hue of 7.5YR or 5YR, value of 3 through 6, and chroma of 2 through 6. It is silty clay, heavy silty clay loam, or clay and is 20 to 40 inches thick. This horizon is medium acid to neutral. The B3 horizon has hue of 7.5YR, 10YR, or 2.5Y; value of 4 or 5; and chroma of 2 through 6. It is silty clay, heavy silty clay loam or clay loam and extends to a depth of more than 60 inches. This horizon is slightly acid to mildly alkaline.

The eroded Mayberry soils are taxadjuncts to the Mayberry series because their surface layer is too thin to be a mollic epipedon.

Mayberry soils are associated on the landscape with Adair, Marshall, Sharpsburg, and Shelby soils. They formed in parent material similar to that of Adair and Northboro soils. They have fewer coarse and medium sand grains and less unweathered mineral material than Adair soils. Mayberry soils are more clayey in the B horizon than Marshall, Sharpsburg, Shelby, and Northboro soils; and unlike Marshall, Sharpsburg, and Shelby soils, they have reddish colors in the B horizon.

692C2—Mayberry clay loam, 5 to 9 percent slopes, moderately eroded. This soil is on low nose slopes and convex side slopes on uplands. The areas are typically 5 to 10 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer, which is about 6 inches thick. The plow layer is 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of Adair soils and Mayberry soils that have silty clay loam surface layers. Also included are small areas of soils with gray clayey subsoils, which are indicated on the soil map by a gray clay symbol.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas are farmed with adjacent soils. Erosion is the main hazard. Capability unit IIIe–2.

692D—Mayberry clay loam, 9 to 14 percent slopes. This soil is on low nose slopes and convex side slopes. The areas are typically 5 to 15 acres in size and are irregular in shape.

This soil has a profile described as representative of the series. The content of organic matter in the plow layer is 3 to 4 percent.

Included with this soil in mapping are small areas of Adair soils and Mayberry soils that have silty clay loam surface layers. Also included are small areas of soils that have a clayey subsoil, which are indicated on the soil map by a spot symbol.

This soil is poorly suited to row crops and well suited to hay and pasture. In most larger areas it is used for hay and pasture, and in the small areas it is mostly farmed with the adjacent soils. Erosion is the main hazard. Capability unit IVe–2.

692D2—Mayberry clay loam, 9 to 14 percent slopes, moderately eroded. This soil is on low nose slopes and convex side slopes on uplands. The areas are typically 5 to 15 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm, dense subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Adair soils and Mayberry soils that have a silty clay loam surface layer. Also included are small areas of soils that have a gray clayey subsoil, which are indicated on the soil map by a spot symbol.

This soil is poorly suited to row crops and well suited to hay and pasture. Most larger areas are used for hay and pasture, and smaller areas are often farmed with the adjacent soils. Fertility is a more limiting factor for this soil than for the uneroded representative soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than for the uneroded representative soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Removing the topsoil causes some management problems because the subsoil has unfavorable properties. Capability unit IVe–2.

Minden series

The Minden series consists of somewhat poorly drained soils on high benches near the Nishnabotna River. Minden soils formed in loess under native vegetation of prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black and very dark gray silty clay loam about 22 inches thick. The subsoil is silty clay loam and extends to a depth of 46 inches. It is dark grayish brown in the upper part and grayish brown in the lower part. The underlying material is grayish brown and light brownish gray silty clay loam that has reddish brown and yellowish red iron stains.

Permeability is moderate, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is low. The organic-matter content is 4 to 6 percent.

Minden soils are used mostly for row crops and nursery crops. They have no major limitations to their use for row crops.

Representative profile of Minden silty clay loam, 0 to 2 percent slopes, in nursery stock, 1,450 feet west and 375 feet south of the northeastern corner of sec. 9, R. 69 N., R. 39 W.

Ap—0 to 8 inches; black (10YR 2/1) light silty clay loam; weak fine granular structure; friable; many fine roots; medium acid; clear smooth boundary.

A12—8 to 16 inches; black (10YR 2/1) light silty clay loam; weak fine subangular blocky structure; friable; many fine roots; medium acid; gradual smooth boundary.

A3—16 to 22 inches; very dark gray (10YR 3/1) light silty clay loam; moderate fine subangular blocky structure; friable; many fine roots; medium acid; gradual smooth boundary.

B2—22 to 30 inches; dark grayish brown (2.5Y 4/2) light silty clay loam; weak fine prismatic structure parting to moderate fine subangular blocky; friable; many fine roots; medium acid; clear smooth boundary.

B3—30 to 46 inches; grayish brown (2.5Y 5/2) light silty clay loam; few coarse to fine distinct reddish brown (5YR 4/4) and yellowish red (5Y 4/6) mottles; weak fine prismatic structure parting to weak medium subangular blocky; friable; many fine roots; medium acid; gradual smooth boundary.

C—46 to 56 inches; grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) light silty clay loam; massive; friable; common reddish brown (5YR 4/4) and yellowish red (5YR 5/6) iron stains; medium acid.

Typically, the solum is more than 40 inches thick. The A horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark brown (10YR 2/2). It is heavy silt loam or light silty clay loam, and is 18 to 24 inches thick. This horizon is medium or slightly acid. The B2 horizon is grayish brown (2.5Y 5/2) or dark grayish brown (2.5Y 4/2). The B horizon is 12 to 24 inches thick. The C horizon is mottled and varies in color. It has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2, 3, or 4. This horizon is medium or slightly acid.

Minden soils are associated on the landscape with Marshall soils and formed in parent material similar to that of Macksburg, Marshall, Sharpsburg, and Winterset soils. They are less clayey in the B horizon than Macksburg, Sharpsburg, and Winterset soils. Minden soils have a thicker A horizon and have lower chroma in the B horizon than Marshall soils.

T299—Minden silty clay loam, 0 to 2 percent slopes. This soil is on high benches near the East Nishnabotna River. It is adjacent to but at a slightly lower elevation than Marshall soils. The areas are typically 5 to 30 acres in size and circular in shape.

This soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till. Included with this soil in mapping are small areas of Marshall soils and some poorly drained areas, which are indicated on the soil map by a special symbol.

This soil is well suited to corn and soybeans. It has no limitations for use as cropland or for nursery crops. It has low potential for landfill and sewage lagoon sites because of the hazard of ground-water pollution. Capability unit I–2.

Nevin series

The Nevin series consists of somewhat poorly drained soils on low stream benches or second bottoms. Nevin soils formed in moderately fine textured alluvium under native vegetation of tall prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black and very dark grayish brown silty clay loam about 24 inches thick. The subsoil is silty clay loam and extends to a depth of 60 inches. It is dark grayish brown in the upper part, dark grayish brown with some grayish brown mottles in the middle part, and grayish brown with yellowish brown mottles in the lower part.

Permeability is moderate to moderately slow, and the available water capacity is high. In the subsoil, the content of available phosphorus is medium and that of available potassium is high. The organic-matter content is 4 to 6 percent.

Nevin soils are used primarily for row crops. They have no serious limitations to their use for row crops.

Representative profile of Nevin silty clay loam, 0 to 2 percent slopes, in a cultivated field, 2,700 feet west and 75 feet north of the southeastern corner of sec. 1, T. 70 N., R. 39 W.

Ap—0 to 8 inches; black (10YR 2/1) light silty clay loam; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

A12—8 to 14 inches; black (10YR 2/1) light silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

A13—14 to 20 inches; black (10YR 2/1) medium silty clay loam; moderate fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

A3—20 to 24 inches; very dark grayish brown (10Y 3/2) medium silty clay loam; very dark brown (10YR 2/2) coatings on peds; moderate fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

B1—24 to 30 inches; dark grayish brown (10YR 4/2) medium silty clay loam; very dark gray (10YR 3/1) coatings on peds; moderate fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B21—30 to 39 inches; dark grayish brown (10YR 4/2) medium silty clay loam; dark gray (10YR 4/1) coatings on peds; moderate fine subangular blocky structure; firm; few black (10YR 2/1) soft bodies; few fine distinct yellowish red (5YR 4/6) iron stains; slightly acid; gradual smooth boundary.

B22—39 to 48 inches; dark grayish brown (10YR 4/2) medium silty clay loam; few fine faint grayish brown (10YR 5/2) mottles; moderate fine subangular blocky structure; firm; common black (10YR 2/1) soft bodies; common fine distinct brown (7.5YR 4/4) iron stains; slightly acid; gradual smooth boundary.

B3—48 to 60 inches; grayish brown (2.5Y 5/2) light silty clay loam; common fine distinct yellowish brown (7.5YR 5/6) mottles; weak fine granular structure; friable; common black (10YR 2/1) soft bodies; common fine distinct brown (7.5YR 4/4) iron stains; slightly acid.

The solum is 36 to 60 inches thick. The A horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) light silty clay loam or silt loam. It is 18 to 30 inches thick and is medium or slightly acid. The B horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 or 3, and contains mottles of higher chroma. It is 23 to 38 inches thick and is medium or slightly acid.

Nevin soils are associated on the landscape with Bremer, Marshall, and Sharpsburg soils. They formed in parent material similar to that of Bremer and Judson soils. Nevin soils lack the low chroma in the B horizon of Bremer soils and are less clayey in the B horizon. They have a thicker A horizon and lower chroma in the upper part of the B horizon than Marshall and Sharpsburg soils. They are more clayey in the B horizon and have a thinner A horizon than Judson soils.

88—Nevin silty clay loam, 0 to 2 percent slopes. This soil is on low stream benches or second bottoms. The areas are typically 10 to 20 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of Bremer soils.

This soil is well suited to row crops, and in most areas it is used for row crops. It has no serious limitation to its use for row crops. Capability unit I–2.

Nodaway series

The Nodaway series consists of moderately well drained soils on flood plains and alluvial fans. Nodaway soils formed in recent medium textured alluvium under native vegetation of mixed trees and grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is very dark grayish brown silt loam about 8 inches thick. The underlying material is stratified, dark grayish brown, grayish brown, and very dark grayish brown silt loam.

Permeability is moderate, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is medium. The organic-matter content is less than 1 percent.

These soils are well suited to row crops and are used for row crops. Flooding is the main hazard.

Representative profile of Nodaway silt loam, 0 to 2 percent slopes, in a cultivated field, 2,640 feet east and 60 feet south of the northwestern corner of sec. 18, T. 67 N., R. 36 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

C1—8 to 15 inches; very dark grayish brown (10YR 3/2) silt loam; common dark grayish brown (10YR 4/2) strata; weak fine granular structure; friable; neutral; gradual smooth boundary.

C2—15 to 60 inches; stratified dark grayish brown (10YR 4/2), grayish brown (10YR 5/2), and very dark grayish brown (10YR 3/2) silt loam; few fine faint yellowish brown (10YR 5/6) mottles; massive; friable; neutral.

The A horizon is very dark gray or very dark grayish brown silt loam or light silty clay loam. It is 6 to 10 inches thick and is slightly acid or neutral. The C horizon has hue of 10YR, value of 3 to 5, and chroma of 2, 3, or 4 with strata of 10YR 2/1, 3/1, or 3/2. It is silt loam or light silty clay loam. It is slightly acid or neutral.

Nodaway soils are associated on the landscape with Colo and Kennebec soils. They formed in parent material similar to that of Kennebec and Judson soils. They have a thinner, lighter colored A horizon than Colo, Judson, and Kennebec soils, none of which are stratified. They are less clayey throughout the profile than Colo soils.

220—Nodaway silt loam, 0 to 2 percent slopes. This soil is near stream channels on flood plains that have recently received sediment and on alluvial fans along tributary streams. The areas are typically 10 to 40 acres in size and irregular in shape.

Included with this soil in mapping are small areas of Kennebec soils and sandy alluvial land. Also included are small areas of Nodaway soils that have thin strata of sand in the profile.

This soil is well suited to row crops and is mostly used for row crops. Flooding is the main hazard. Capability unit IIw–2.

Northboro series

The Northboro series consists of moderately well drained soils on points of ridgetops and on convex side slopes on uplands. Northboro soils formed in sediment from weathered glacial till under a vegetation of prairie grasses. Slopes are 5 to 14 percent.

In a representative profile the surface layer is silt loam about 14 inches thick. It is very dark gray in the upper part and dark brown in the lower part. The upper part of the subsoil extends to a depth of 40 inches. It has yellowish red mottles and is brown and reddish brown silt loam throughout. The lower part of the subsoil is brown loam and grayish brown and yellowish brown clay loam and extends to a depth of 70 inches.

Permeability is moderate, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is very low. The organic-matter content is 2 to 4 percent.

These soils are used for row crops, hay, or pasture. Erosion is the main hazard.

Representative profile of Northboro silt loam, 5 to 9 percent slopes, in pasture, 330 feet east and 330 feet north of the southwestern corner of sec. 30, T. 69 N., R. 37 W.

A1—0 to 10 inches; very dark gray (10YR 3/1) silt loam; weak fine subangular blocky structure parting to weak fine granular; friable; thin discontinuous sand and silt coatings on ped faces that are light gray

(10YR 6/1) when dry; medium acid; gradual smooth boundary.

A3—10 to 14 inches; dark brown (10YR 3/3) silt loam; very dark grayish brown (10YR 3/2) coatings on peds; weak fine subangular blocky structure parting to weak fine granular; friable; thin discontinuous sand and silt coatings on ped faces that are light gray (10YR 6/1) when dry; slightly acid; gradual smooth boundary.

B1—14 to 20 inches; brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/2) coatings on peds; few fine faint yellowish red (5YR 4/6) mottles; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B2—20 to 28 inches; brown (7.5YR 4/4) silt loam; few fine faint yellowish red (5YR 4/6) mottles; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B3—28 to 40 inches; reddish brown (5YR 4/4) silt loam; few fine faint yellowish red (5YR 4/6) mottles; weak fine subangular blocky structure; friable; few fine and medium sand grains; slightly acid; clear smooth boundary.

IIB21—40 to 56 inches; brown (7.5YR 4/4) heavy loam; few fine faint yellowish red (5YR 4/6) mottles; moderate medium subangular blocky structure; friable; many medium and coarse sand grains; few pebbles; few black (10YR 2/1) soft bodies; neutral; abrupt smooth boundary.

IIB22t—56 to 70 inches; grayish brown (10YR 5/2) and yellowish brown (10YR 5/4, 5/6) clay loam; moderate medium subangular blocky structure; firm; stone line at 56 inches; many coarse and medium sand grains; thick continuous clay films on ped faces; neutral.

The solum is 36 to more than 60 inches thick. The A horizon has hue of 10YR or 7.5YR, value of 2 or 3, and chroma of 1 or 2. It is silt loam or silty clay loam and is 10 to 18 inches thick. The B horizon has hue of 5YR or 7.5YR, value of 4 or 5, and chroma of 4 through 6. It is silt loam or silty clay loam and is 26 to 50 inches thick. In many places there is no IIB2 horizon above 60 inches. The IIB2 horizon varies in color and texture, but it is generally clay loam or loam. It has hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 to 6 and has few to many low-chroma mottles.

The eroded Northboro soils are taxadjuncts to the Northboro series because their surface layer is not thick enough to be a mollic epipedon.

Northboro soils are associated on the landscape with Marshall, Sharpsburg, and Shelby soils. They formed in parent material similar to that of Adair and Mayberry soils. Unlike Marshall, Sharpsburg, and Shelby soils, Northboro soils have a reddish B horizon or reddish mottles in the B horizon. They are less clayey in the B horizon and do not have the low-chroma mottles characteristic of Adair and Mayberry soils.

751C—Northboro silt loam, 5 to 9 percent slopes. This soil is on points of ridges and convex side slopes on uplands in areas that are typically long and narrow and 3 to 5 acres in size.

This soil has the profile described as representative of the series. The plow layer is 3 to 4 percent organic matter. Included with this soil in mapping are small areas of Marshall and Sharpsburg soils and some Northboro soils that are silty clay loam throughout.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas are farmed with adjacent soils. Erosion is the main hazard. Capability unit IIIe-1.

751C2—Northboro silt loam, 5 to 9 percent slopes, moderately eroded. This soil is on points of secondary ridges and convex side slopes on uplands. The areas are typically long and narrow and 3 to 5 acres in size.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer that is very dark grayish brown silt loam or silty clay loam about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils and Northboro soils that are silty clay loam throughout.

This soil is moderately suited to row crops and well suited to hay and pasture crops. In most areas it is farmed with adjacent soils. Fertility is a more limiting factor for this soil than for the uneroded Northboro soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Removing the topsoil causes severe management problems because of unfavorable subsoil properties. Capability unit IIIe-1.

751D—Northboro silt loam, 9 to 14 percent slopes. This soil is on convex side slopes on uplands. The areas are typically 5 to 10 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer, which is about 10 inches thick. The content of organic matter in the plow layer is 3 to 4 percent.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils and some Northboro soils that are silty clay loam throughout.

This soil is moderately suited to row crops and well suited to hay and pasture. In most areas it is farmed with adjacent soils. Erosion is the main hazard. Capability unit IIIe-1.

751D2—Northboro silt loam, 9 to 14 percent slopes, moderately eroded. This soil is on convex side slopes on uplands in areas that are typically 5 to 10 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a plow layer that is very dark grayish brown silt loam or silty clay about 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Marshall and Sharpsburg soils and some Northboro soils that are silty clay loam throughout.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas are farmed with adjacent soils. Fertility is a more limiting factor for this soil than for the uneroded Northboro soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Removing the topsoil causes severe management problems because of unfavorable subsoil properties. Capability unit IIIe-1.

Olmitz series

The Olmitz series consists of well drained or moderately well drained soils on alluvial fans and foot slopes. Olmitz soils formed in medium textured local alluvium under native vegetation of prairie grasses. Slopes are 3 to 9 percent.

In a representative profile the surface layer is very dark gray loam in the upper part, very dark brown loam in the middle part, and very dark grayish brown light clay loam in the lower part. It is about 32 inches thick. The subsoil is light clay loam that extends to a depth of 60 inches. It is dark brown in the upper part and brown in the lower part.

Permeability is moderate, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is very low. The organic-matter content is 4 to 6 percent.

These soils are used mainly for row crops. Erosion is the main hazard.

Representative profile of Olmitz loam, 2 to 5 percent slopes, in a cultivated field, 594 feet south and 200 feet east of the northwestern corner of sec. 4, T. 68 N., R. 36 W.

Ap—0 to 8 inches; very dark gray (10YR 3/1) loam; gray (10YR 5/1) dry; weak fine granular structure; friable; slightly acid; gradual smooth boundary.

A12—8 to 13 inches; very dark brown (10YR 2/2) loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13—13 to 21 inches; very dark brown (10YR 2/2) loam; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; gradual smooth boundary.

A3—21 to 32 inches; very dark grayish brown (10YR 3/2) light clay loam; very dark gray (10YR 3/1) coating on peds; moderate medium subangular blocky structure; friable; neutral; gradual smooth boundary.

B1—32 to 39 inches; dark brown (10YR 3/3) light clay loam; common very dark grayish brown (10YR 3/2) coatings on ped faces; moderate medium subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—39 to 48 inches; brown (10YR 4/3) light clay loam; few very dark grayish brown (10YR 3/2) coatings on ped faces; moderate fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B3—48 to 60 inches; brown (10YR 4/3) light clay loam; weak fine subangular blocky structure; friable; medium acid.

Typically, the solum is more than 40 inches thick. The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or very dark gray (10YR 3/1). It is 24 to 36 inches thick and is loam or light clay loam. This horizon is neutral to medium acid. In some places, colors with value of 3 and chroma of 2 to 3 extend into the B horizon to a depth of 40 inches, but below this the crushed or kneaded ped has value of 4. The B horizon is clay loam and is neutral or medium acid.

Olmitz soils are associated on the landscape with Colo, Gara, Judson, and Shelby soils. They are more sandy than Colo and Judson soils and are downslope from and have a thicker A horizon than Gara and Shelby soils.

273B—Olmitz loam, 2 to 5 percent slopes. This soil is on alluvial fans and foot slopes adjacent to bottom lands in areas that are typically 10 to 30 acres in size and narrow or crescent in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Judson soils and small areas of Olmitz soils that have a loam subsoil.

This soil is well suited to row crops and is mostly used for row crops. Erosion is the main hazard. Capability unit IIe-1.

273C—Olmitz loam, 5 to 9 percent slopes. This soil is on alluvial fans and foot slopes adjacent to the bottom lands. The areas are typically 10 to 20 acres in size and are long and narrow or crescent in shape.

This soil has a profile similar to the one described as representative of the series, except that it is slightly coarser.

Included with this soil in mapping are small areas of Judson soils and small areas of Olmitz soils that have a loam subsoil.

This soil is moderately suited to row crops and well suited to hay and pasture. It is mostly used for row crops. Erosion is the main hazard. Capability unit IIIe-1.

Sharpsburg series

The Sharpsburg series consists of moderately well drained soils on convex ridgetops, upland divides, convex side slopes, and high stream benches. Sharpsburg soils formed in loess under native vegetation of tall prairie grasses. Slopes are 0 to 14 percent.

In a representative profile the surface layer is very dark gray silty clay loam about 16 inches thick. The subsoil is silty clay loam that extends to a depth of 56 inches. It is very dark grayish brown in the upper part, brown to dark yellowish brown in the middle part, and mottled grayish brown and dark yellowish brown in the lower part. The underlying material is mottled light brownish gray and brown silty clay loam.

Permeability is moderately slow, and the available water capacity is high. The content of available phosphorus and potassium in the subsoil is low. The organic-matter content is 2 to 4 percent in uneroded areas.

These soils are used mostly for row crops, hay, and pasture. Erosion is the main hazard.

Representative profile of Sharpsburg silty clay loam, 2 to 5 percent slopes, in an alfalfa field, 1,260 feet south and 1,290 feet west of the northeastern corner of sec. 14, T. 67 N., R. 37 W.

Ap—0 to 9 inches; very dark gray (10YR 3/1) light silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; medium acid; gradual smooth boundary.

A12—9 to 16 inches; very dark gray (10YR 3/1) medium silty clay loam; weak fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B1—16 to 23 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam; weak fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B2t—23 to 34 inches; brown (10YR 4/3) to dark yellowish brown (10YR 4/4) heavy silty clay loam; weak medium prismatic structure parting to moderate fine subangular blocky; friable; few thin discontinuous clay films on ped faces; medium acid; gradual smooth boundary.

B31—34 to 46 inches; mottled grayish brown (10YR 5/2) and dark yellowish brown (10YR 4/4) medium silty clay loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine distinct brown (7.5YR 4/4) iron stains; few black (10YR 2/1) soft bodies; slightly acid; gradual smooth boundary.

B32—46 to 56 inches; mottled grayish brown (10YR 5/2) and dark yellowish brown (10YR 4/4) medium silty clay loam; massive; friable; few fine faint brown (7.5YR 4/4) iron stains; slightly acid; gradual smooth boundary.

C—56 to 60 inches; mottled light brownish gray (10YR 6/2) and brown (10YR 5/3) light silty clay loam; massive; friable; neutral.

The solum is 42 to 72 inches thick. The A horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) light or medium silty clay loam. It is 10 to 20 inches thick and is slightly to strongly acid. The B2 horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) that has mottles in hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 through 8. It is medium or heavy silty clay loam, and it is medium or slightly acid. The B3 and upper C horizons are mottled and have hue of 10YR, 2.5Y, or 5Y, value of 4, 5, and 6, and chroma of 2, 3, or 5.

Sharpsburg soils are associated on the landscape with Macksburg and Winterset soils on benches and with Adair and Shelby soils on uplands. They formed in parent material similar to that of Ladoga, Macksburg, Marshall, Minden, and Winterset soils. Sharpsburg soils do not have the low chroma characteristic of the upper part of the B horizon of Macksburg, Winterset, and Minden soils. They are less sandy throughout the profile than Adair and Shelby soils, which formed in glacial till. Sharpsburg soils have a thicker A horizon than Ladoga soils and do not have an A2 horizon. They are more clayey in the B horizon than Marshall soils.

370—Sharpsburg silty clay loam, 0 to 2 percent slopes. This soil is on broad ridgetops and divides on uplands. The areas are typically 10 to 30 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thicker surface layer, which is about 18 inches thick. The plow layer is 3 to 4 percent organic matter.

This soil is well suited to row crops. It is mostly used for row crops. This soil has no serious limitations to use for crops. Capability unit I–1.

370B—Sharpsburg silty clay loam, 2 to 5 percent slopes. This soil is on ridgetops on uplands. The areas are typically 15 to 40 acres in size and irregular in shape.

This soil has the profile described as representative of the series. The content of organic matter in the plow layer is 3 to 4 percent. Included with this soil in mapping are small areas of Ladoga soils.

This soil is well suited to row crops, and in most areas it is used for row crops. Erosion is the main hazard. Capability unit IIe–1.

370B2—Sharpsburg silty clay loam, 2 to 5 percent slopes, moderately eroded. This soil is on ridgetops on uplands. The areas are typically 5 to 10 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series except that the plow layer is very dark grayish brown silty clay loam about 6 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in the sidehills. Included in mapping are small areas of Ladoga soils.

This soil is well suited to row crops, and in most areas it is used for row crops. Fertility is a more limiting factor for this soil than for the uneroded Sharpsburg soils. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Capability unit IIe–1.

370C—Sharpsburg silty clay loam, 5 to 9 percent slopes. This soil is on narrow ridgetops and on side slopes on uplands. The areas are typically 5 to 20 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a slightly thinner surface layer, which is about 12 inches thick. The content of organic matter in the plow layer is 3 to 4 percent. Included with this soil in mapping are small areas of Ladoga soils.

This soil is moderately suited to row crops and well suited to hay and pasture, and in most areas it is used for these crops. Erosion from runoff is the main hazard. Capability unit IIIe–1.

370C2—Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded. This soil is on narrow ridgetops and on side slopes on uplands. The areas are typically 5 to 15 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that the plow layer is very dark grayish brown silty clay loam 7 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm subsoil. In some places the subsoil is exposed at the shoulder of slopes or near drains in sidehills. Included with this soil in mapping are small areas of Ladoga soils.

This soil is moderately suited to row crops and well suited to hay and pasture, and in most areas it is used for these crops. Fertility is a more limiting factor for this soil than for the uneroded Sharpsburg soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Capability unit IIIe–1.

370D—Sharpsburg silty clay loam, 9 to 14 percent slopes. This soil is on side slopes on uplands. Areas are typically 15 to 40 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer, which is about 10 inches thick. The plow layer is 3 to 4 percent organic matter. Included with this soil in mapping are small areas of Ladoga soils.

This soil is moderately suited to row crops and well suited to hay and pasture, and in most areas it is used for these crops. Erosion from runoff is the main hazard. Capability unit IIIe–1.

370D2—Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes on uplands. Areas are typically 15 to 40 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that the plow layer is very dark grayish brown silty clay loam about 5 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on this firm subsoil. Included with this soil in mapping are small areas of Ladoga soils.

This soil is moderately suited to row crops and well suited to hay and pasture, and in most areas it is used for these crops. Fertility is a more limiting factor for this soil than for the uneroded Sharpsburg soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. It also requires a higher level of management and is more erodible. Erosion from runoff is the main hazard. Capability unit IIIe–1.

T370B—Sharpsburg silty clay loam, 2 to 5 percent complex slopes. This soil is on broad benches near the Nodaway and East Nodaway Rivers. The areas are typically 10 to 30 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thicker surface layer, which is about 18 inches thick. This soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till. Included with this soil in mapping are small areas of Macksburg soils.

This soil is well suited to row crops and is mostly used for row crops. Erosion is the main hazard. Conservation practices are difficult because of the short, irregular slopes. This soil has low potential for landfills and sewage lagoons because of the danger of groundwater pollution. Capability unit IIe–1.

T370C—Sharpsburg silty clay loam, 5 to 9 percent complex slopes. This soil is on short, narrow side slopes on benches near the Nodaway and East Nodaway Rivers. The areas are typically 5 to 10 acres in size and are long and narrow in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a slightly thinner surface layer, which is about 14 inches thick. This soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till.

This soil is moderately suited to row crops and well suited to hay and pasture. In most areas it is used for these crops. Erosion is the main hazard. Conservation practices are difficult because of the short, irregular slopes. This soil has low potential for landfills and sewage lagoons because of the danger of ground-water pollution. Capability unit IIIe–1.

Shelby series

The Shelby series consists of moderately well drained soils on convex side slopes on uplands. Shelby soils formed in glacial till under native vegetation of tall prairie grasses. Slopes are 9 to 25 percent.

In a representative profile the surface layer is black or very dark brown clay loam about 10 inches thick. The subsoil extends to a depth of 38 inches. It is very dark grayish brown and brown clay loam in the upper part, brown and dark yellowish brown clay loam in the middle part, and brown clay loam in the lower part. The underlying material is brown and light brownish gray clay loam.

The content of available phosphorus and potassium in the subsoil is very low. The available water capacity is high, and permeability is moderately slow. The organic-matter content is 2 to 4 percent in uneroded areas.

The more sloping Shelby soils are used mostly for pasture and hay crops, and the less sloping soils are sometimes used for row crops. Erosion is the major hazard.

Representative profile of Shelby clay loam, 9 to 14 percent slopes, in pasture, 1,400 feet west and 500 feet north of the southeastern corner of sec. 11, T. 68 N., R. 39 W.

A1—0 to 10 inches; black (10YR 2/1) and very dark brown (10YR 2/2) clay loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; neutral; gradual smooth boundary.

B1—10 to 18 inches; very dark grayish brown (10YR 3/2) and brown (10YR 4/3) clay loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—18 to 29 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) clay loam; weak fine subangular blocky structure; firm; slightly acid; gradual smooth boundary.

B3—29 to 38 inches; brown (10YR 4/3) clay loam; weak fine subangular blocky structure; firm; few iron stains; slightly acid; gradual smooth boundary.

C—38 to 60 inches; brown (10YR 4/3) and light brownish gray (2.5Y 6/2) clay loam; massive with vertical cleavage faces; firm; black (10YR 2/1) iron-manganese stains on ped faces; prominent accumulations of soft lime in lower part; neutral.

Typically, the solum is 36 to 50 inches thick, but it ranges from 30 to 60 inches. The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1). This horizon is clay loam, loam, or silty clay loam. It is 10 to 18 inches thick in uneroded areas, and it is neutral or slightly acid. The B2 horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4). It is 10 to 24 inches thick.

Shelby soils are associated on the landscape with Adair, Marshall, and Sharpsburg soils. They formed in parent material similar to that of Gara soils. Shelby soils are more sandy than Marshall and Sharpsburg soils. Unlike Adair soils, Shelby soils do not have a reddish hue in the B horizon. They have a thicker A1 horizon than Gara soils and, unlike Gara soils, they do do not have an A2 horizon.

24D—Shelby clay loam, 9 to 14 percent slopes. This soil is on side slopes on uplands. The areas are typically 5 to 25 acres in size and are irregular in shape.

This soil has the profile described as representative of the series. The plow layer is 3 to 4 percent organic matter.

Included with this soil in mapping are small areas of Adair and Gara soils and some small areas of Shelby soils that have a loam surface layer.

This soil is moderately suited to row crops and well suited to hay and pasture. Most areas are used for hay and pasture. Erosion is the main hazard. Capability unit IIIe–1.

24D2—Shelby clay loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes on uplands. The areas are typically 5 to 25 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that the plow layer is very dark grayish brown clay loam about 6 inches thick. The plow layer contains 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm, dense subsoil. In places the subsoil is exposed at the shoulder of slopes or near drains on hillsides. Included with this soil in mapping are small areas of Adair and Gara soils.

This soil is moderately suited to row crops and well suited to hay and pasture. It is used mostly for hay and pasture. Fertility is a more limiting factor for this soil than for the uneroded Shelby soil. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded soil. This soil also requires a higher level of management, and it is more erodible. Erosion from runoff is the main hazard. Removing the topsoil causes severe management problems because of unfavorable subsoil properties. Capability unit IIIe–1.

24E—Shelby clay loam, 14 to 18 percent slopes. This soil is on side slopes on uplands in areas that are typically 5 to 25 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that it has a thinner surface layer. The surface layer is about 8 inches thick. It is 3 to 4 percent organic matter.

Included with this soil in mapping are small areas of Gara soils and small areas of Shelby soils that have a loam surface layer.

This soil is poorly suited to row crops and well suited to hay and pasture. It is used mostly for hay and pasture. Erosion is the main hazard. Capability unit IVe–1.

24E2—Shelby clay loam, 14 to 18 percent slopes, moderately eroded. This soil is on side slopes on uplands. The areas are typically 5 to 25 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that the plow layer is very dark grayish brown clay loam about 6 inches thick. This layer is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm, dense subsoil. In places the subsoil is exposed at the shoulder of slopes or near drains on hillsides. Included with this soil in mapping are small areas of Gara soils.

This soil is poorly suited to row crops and well suited to hay and pasture crops. It is used mostly for hay and pasture (fig. 9). Fertility is a more limiting factor for this soil than for the uneroded Shelby soils. This soil tends to be cloddy when tilled, making seedbed preparation difficult and requiring greater production input than the uneroded representative soil. This soil requires a higher level of management, and it is more erodible than the representative soil. Erosion from runoff is the main hazard. Removing the topsoil causes severe management problems because of the unfavorable subsoil properties. Capability unit IVe–1.

24F2—Shelby clay loam, 18 to 25 percent slopes, moderately eroded. This soil is on side slopes on uplands. The areas are typically 10 to 30 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that its plow layer is very dark grayish brown clay loam about 6 inches thick and is 2 to 3 percent organic matter. Plowing has mixed some subsoil with the plow layer, which rests directly on the firm, dense subsoil. In places the subsoil is exposed at the shoulder of slopes or near drains on hillsides. Included with this soil in mapping are small areas of Gara soils.

This soil is generally not suited to row crops. It is suited to hay and pasture and is used mostly for hay

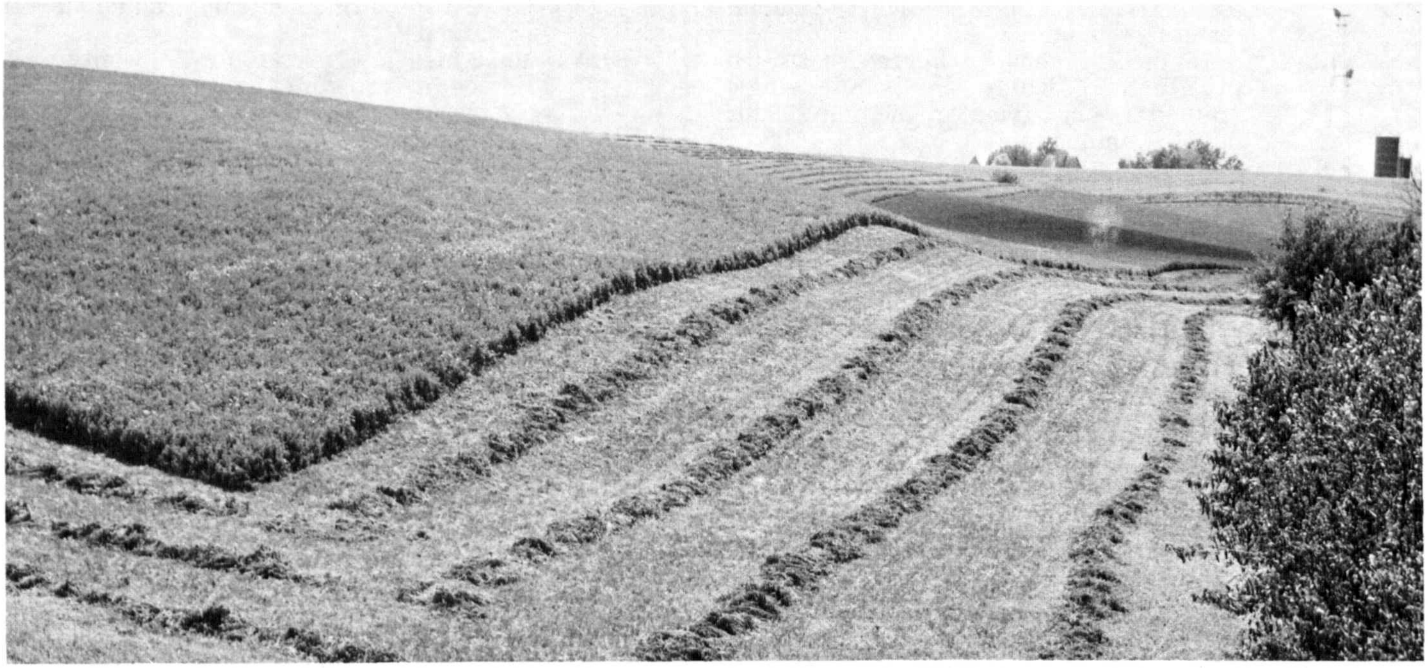


Figure 9.—**Alfalfa on moderately steep Shelby soils.**

and pasture. Erosion is the main hazard. This soil is more erodible than the uneroded Shelby soil. Removing the topsoil causes severe management problems because of unfavorable subsoil properties. Capability unit VIe–1.

93D—Shelby-Adair clay loams, 9 to 14 percent slopes. This complex is on side slopes on uplands. It is about 55 percent Shelby clay loam and 45 percent Adair silty clay loam. Shelby soils are on the lower part of the side slopes, and Adair soils are on the upper part. The areas are typically 5 to 15 acres in size and are irregular in shape.

Included with this complex in mapping are small areas of Mayberry and Northboro soils.

This complex is poorly suited to corn and soybeans and well suited to pasture and hay crops. Most areas are used for hay and pasture. Erosion is the main hazard. Capability unit IVe–1.

93D2—Shelby-Adair clay loams, 9 to 14 percent slopes, moderately eroded. This complex is on side slopes on uplands in areas that are typically 5 to 15 acres in size and irregular in shape. It is about 55 percent Shelby clay loam and 45 percent Adair clay loam. Shelby soils are on the lower part of the side slopes, and Adair soils are on the upper part.

Included with this complex in mapping are small areas of Mayberry and Northboro soils.

This complex is poorly suited to corn and soybeans and well suited to pasture and hay crops. Most areas of these soils are used for pasture and hay crops. Erosion is the main hazard. Capability unit IVe–1.

93E2—Shelby-Adair clay loams, 14 to 18 percent slopes, moderately eroded. This complex is on side slopes on uplands in areas that are 5 to 15 acres in size and irregular in shape. It is about 70 percent Shelby clay loam and 30 percent Adair silty clay loam. Shelby soils are on the lower part of side slopes, and Adair soils are on the upper part.

Included with this complex in mapping are small areas of Mayberry and Northboro soils.

This complex is generally not suited to corn and soybeans. It is better suited to hay and pasture, and most areas are used for hay and pasture. Erosion is the main hazard. Capability unit VIe–1.

Sparta series

The Sparta series consists of excessively drained soils on upland ridgetops and side slopes and, in a few places, on benches. Sparta soils formed in wind-deposited sand under native vegetation of mixed prairie grasses and widely spaced trees. Slopes are 5 to 14 percent.

In a representative profile the surface layer is very dark grayish brown loamy fine sand about 15 inches thick. The subsoil is brown sand; it extends to a depth of about 25 inches. The underlying material is yellowish brown sand.

Permeability is very rapid, and the available water capacity is very low. The content of available phosphorus and potassium in the subsoil is very low. The organic-matter content is less than 1 percent.

These soils are used mainly for pasture. Some areas are a source of sand for construction. Droughtiness is the main hazard, but erosion is also a hazard.

Representative profile of Sparta loamy fine sand, 5 to 14 percent slopes, in a cultivated field, 100 feet east and 40 feet south of the center of sec. 22, T. 69 N., R. 36 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) loamy fine sand, grayish brown (10YR 5/2) dry; single grained;

very friable; slightly acid; gradual smooth boundary.

A12—7 to 15 inches; very dark grayish brown (10YR 3/2) loamy fine sand; single grained; very friable; medium acid; smooth boundary.

B—15 to 25 inches; brown (10YR 4/3) medium sand; single grained; loose; slightly acid; gradual smooth boundary.

C—25 to 60 inches; yellowish brown (10YR 5/6) medium sand; single grained; loose; slightly acid.

The solum is 24 to 40 inches thick. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is loamy fine sand, loamy sand, or sand, and is 10 to 24 inches thick. The B horizon has hue of 10YR or 7.5YR; value of 4, 5, or 6; and chroma of 3 through 6. It is sand, fine sand, loamy sand, or loamy fine sand. This horizon is 10 to 15 inches thick and is medium or slightly acid. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 3 through 6. It is slightly acid or neutral.

Sparta soils are associated on the landscape with Marshall, Ladoga, and Sharpsburg soils. They are more sandy than the associated soils.

41D—Sparta loamy fine sand, 5 to 14 percent slopes. This soil is on narrow ridgetops and side slopes in the uplands and, in a few places, on benches. The areas are typically 5 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of Sharpsburg and Ladoga soils.

This soil generally is not suited to row crops but is suited to hay and pasture. Most areas are used for pasture. Droughtiness is the main hazard, but erosion is also a hazard. Capability unit VIs–1.

Wabash series

The Wabash series consists of very poorly drained soils in slack-water areas of large flood plains. Wabash soils formed in fine textured alluvium under native vegetation of marsh grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silty clay about 19 inches thick. The subsoil is silty clay and extends to a depth of 60 inches. It is black in the upper part, very dark gray in the middle part, and dark gray in the lower part.

Permeability is very slow, and the available water capacity is moderate. The content of available phosphorus and potassium in the subsoil is low. The organic-matter content is 4 to 6 percent except in areas that have silt loam overwash.

These soils are used mostly for row crops. Wetness is the major limitation.

Representative profile of Wabash silty clay, 0 to 2 percent slopes, in pasture, 2,000 feet west and 400 feet south of the northeastern corner of sec. 16, T. 68 N., R. 36 W.

A1—0 to 9 inches; black (10YR 2/1) silty clay, dark gray (10YR 4/1) dry; moderate medium subangular blocky structure; firm; medium acid; gradual smooth boundary.

A12—9 to 19 inches; black (N 2/0) silty clay; moderate medium subangular blocky structure; firm; neutral; gradual smooth boundary.

B1—19 to 32 inches; black (10YR 2/1) silty clay; moderate medium subangular blocky structure; firm; neutral; gradual smooth boundary.

B21g—32 to 48 inches; very dark gray (N 3/0) silty clay; moderate medium subangular blocky structure; firm; prominent slickensides; neutral; gradual smooth boundary.

B22g—48 to 60 inches; dark gray (5Y 4/1) silty clay; moderate medium subangular blocky structure; firm; prominent slickensides; neutral.

The solum is 40 to more than 60 inches thick. The A horizon is 10YR to 5Y or neutral in hue and has value of 2 or 3 and chroma of 2 or less. It is silty clay or silty clay loam. In areas of recent overwash, the A horizon is silt loam. This horizon is 18 to 28 inches thick and is medium acid to neutral. The B horizon is similar to the A horizon in color, but at a depth of more than 36 inches value of 4 or 5 is included. It is 21 to 50 inches thick.

Wabash soils are associated on the landscape with Colo soils. They formed in parent material similar to that of Zook soils. They are more clayey in the 10- to 40-inch section of their profiles than Colo and Zook soils.

172—Wabash silty clay, 0 to 2 percent slopes. This soil is in slack-water areas on large flood plains. The areas are typically 15 to 40 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Zook soils.

This soil is moderately suited to row crops if wetness is controlled, but it is better suited to hay and pasture crops. Wetness and flooding are the main limitations. The surface layer dries slowly after rain, and tillage operations are delayed. The power required to till this soil is greater than for any other soil in the county. Capability unit IIIw–1.

248—Wabash silty clay loam, 0 to 2 percent slopes. This soil is in slack-water areas on large flood plains. The areas are typically 5 to 40 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that the surface layer is silty clay loam. The content of organic matter in the plow layer is 4 to 5 percent.

Included with this soil in mapping are small areas of Zook soils.

This soil is moderately suited to row crops if wetness is controlled. It is well suited to hay and pasture crops. Most areas are used for row crops. Wetness and flooding are the main limitations. Because the surface layer dries slowly after rain, tillage operations are sometimes delayed. More power is required to till this soil than most other bottom-land soils. Capability unit IIIw–1.

248+—Wabash silt loam, overwash, 0 to 2 percent slopes. This soil is in slack-water areas on large flood plains. The areas are typically 10 to 30 acres in size and irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that 6 to 15 inches of recently deposited, very dark grayish brown to dark grayish brown silty material overlies the original surface layer of black silty clay loam. The content of organic matter in the plow layer is 2 to 3 percent.

Included with this soil in mapping are small areas of Zook soils.

This soil is moderately suited to row crops if wetness is controlled. It is well suited to hay and pasture. Most areas are used for row crops. Wetness and flooding are the main limitations. Because the overwash is silt loam, this soil dries faster than the other Wabash soils. Less power is required to till this soil than the other Wabash soils, and tilth generally is better. Capability unit IIIw-1.

Winterset series

The Winterset series consists of poorly drained soils on high stream benches near the Nodaway and East Nodaway Rivers. Winterset soils formed in loess under native vegetation of tall prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black light silty clay loam in the upper part, very dark brown light silty clay loam in the middle part, and very dark gray medium silty clay loam in the lower part. It is about 24 inches thick. The subsoil extends to a depth of 48 inches. It is very dark gray and dark gray light silty clay in the upper part, gray heavy silty clay loam in the middle part, and mottled gray and yellowish brown medium silty clay loam in the lower part. The upper and middle parts of the subsoil have a few yellowish brown mottles. The underlying material is light olive gray and strong brown light silty clay loam.

Permeability is moderately slow or slow, and the available water capacity is high. In the subsoil the content of available phosphorus is low to medium and that of available potassium is medium. The organic-matter content is 4 to 6 percent.

These soils are used mainly for row crops. Wetness is the main limitation.

Representative profile of Winterset silty clay loam, 0 to 2 percent slopes, in pasture, 100 feet east and 60 feet south of the southeastern corner of sec. 18, T. 68 N., R. 36 W.

A11—0 to 12 inches; black (10YR 2/1) light silty clay loam; weak fine granular structure; friable; many fine roots; slightly acid; gradual smooth boundary.

A12—12 to 19 inches; very dark brown (10YR 2/2) light silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; common fine roots; slightly acid; gradual smooth boundary.

A3—19 to 24 inches; very dark gray (10YR 3/1) medium silty clay loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B21t—24 to 31 inches; very dark gray (10YR 3/1) and dark gray (10YR 4/1) light silty clay; few fine faint yellowish brown (10YR 5/4, 5/6) mottles; weak medium subangular blocky structure; firm; thin discontinuous clay films on ped faces; few fine black (10YR 2/1) bodies; neutral; gradual smooth boundary.

B22t—31 to 38 inches; gray (5Y 5/1) heavy silty clay loam; few fine faint yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; firm, thin discontinuous clay films on ped faces; few fine black (10YR 2/1) bodies; neutral; gradual smooth boundary.

B3—38 to 48 inches; gray (5Y 5/1) and yellowish brown (10YR 5/6) medium silty clay loam; weak fine subangular blocky structure; firm; few fine black (10YR 2/1) bodies; neutral; gradual smooth boundary.

C—48 to 60 inches; light olive gray (5Y 6/2) and strong brown (7.5YR 5/6) light silty clay loam; massive; friable; few fine and coarse black (10YR 2/1) bodies; neutral.

The solum is 48 to 72 inches thick. The A11 or Ap horizon is black (10YR 2/1 or N 2/0), but the lower part of the A horizon is very dark brown (10YR 2/2) or very dark gray (10YR 3/1) in places. The A horizon is 16 to 24 inches thick. The upper part of the B2 horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2, and the lower part has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. Few to many mottles are in this horizon. They have hue of 10YR or 7.5YR, value of 4 or 5, and chroma of 4 through 8. The B2t horizon averages 39 percent clay, and the B21t horizon has the most clay. The B3 horizon and upper part of the C horizon have hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 1 or 2. Mottles are similar to those of the B2 horizon. These layers are medium or light silty clay loam.

Winterset soils are associated on the landscape with Sharpsburg and Macksburg soils. They formed in parent material similar to that of Ladoga, Marshall, Minden, Macksburg, and Sharpsburg soils. Winterset soils have lower chroma in the upper part of the B2 horizon than Sharpsburg and Macksburg soils. They differ from Ladoga soils in having a thicker A horizon and no A2 horizon. Winterset soils have a thicker A horizon than Marshall soils and have a higher clay content in the B2 horizon than Marshall and Minden soils.

T369—Winterset silty clay loam, 0 to 2 percent slopes. This soil is on broad, high stream benches near the East Nodaway and Nodaway Rivers. It is in shallow drainageways and in slight depressions on benches. The areas are typically 10 to 40 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of Macksburg soils and some small, very poorly drained depressions. This soil formed in loess on benches. This loess differs from that on uplands because it is underlain by sandy alluvial sediment rather than by glacial till.

This soil is well suited to row crops, and large areas are used for row crops. Wetness is the main limitation. This soil has low potential for landfills and sewage lagoons because there is a danger of ground-water pollution. Capability unit IIw-1.

Zook series

The Zook series consists of poorly drained soils on low flat flood plains. Zook soils formed in moderately fine textured alluvium under native vegetation of prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam in the upper part and black silty clay in the lower part. It is about 36 inches thick. The subsoil is very dark gray light silty clay with grayish brown mottles; it extends to a depth of 46 inches. The underlying material is grayish brown and dark gray heavy silty clay loam.

Permeability is slow, and the available water capacity is high. In the subsoil the content of available phosphorus is low and that of available potassium is very low. The organic-matter content is 4 to 6 percent.

These soils are used mostly for row crops. Wetness is the main limitation.

Representative profile of Zook silty clay loam, 0 to 2 percent slopes, in a cultivated field, 2,140 feet north and 1,900 feet west of the southeastern corner of sec. 4, T. 69 N., R. 39 W.

Ap—0 to 7 inches; black (10YR 2/1) heavy silty clay loam; dark gray (10YR 4/1) dry; weak fine granular structure; friable; neutral; gradual smooth boundary.

A12—7 to 12 inches; black (10YR 2/1) medium silty clay loam; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; gradual smooth boundary.

A13—12 to 21 inches; black (10YR 2/1) heavy silty clay loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A3—21 to 36 inches; black (10YR 2/1) light silty clay; moderate fine subangular blocky structure; firm; thick continuous clay films on ped faces; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

Bg—36 to 46 inches; very dark gray (10YR 3/1) light silty clay; few fine faint grayish brown (2.5Y 5/2) mottles; moderate fine subangular blocky structure; firm; thick continuous clay films on ped faces; few black (10YR 2/1) soft bodies; neutral; gradual smooth boundary.

C—46 to 60 inches; grayish brown (2.5Y 5/2) and dark gray (10YR 4/1) heavy silty clay loam; weak fine prismatic structure parting to moderate fine subangular blocky; firm; thick continuous clay films on ped faces; few black (10YR 4/1) soft bodies; neutral.

The solum is 36 to 64 inches thick. The A horizon is black (N 2/0 or 10YR 2/1) silty clay loam or silty clay. In areas of recent overwash, this horizon is silt loam. It is 26 to 40 inches thick, and it is medium acid to neutral. The B horizon is weakly expressed, and in some places there is no B horizon. The B and C horizons have hue of 10YR to 5Y, value of 3, 4, or 5, and chroma of 1. Mottles of higher chroma are below a depth of 35 inches in some profiles. The C horizon is light silty clay or heavy silty clay loam.

Zook soils are associated on the landscape with Colo and Wabash soils. They are more clayey in the 10- to 40-inch section of the profile than Colo soils and are less clayey in this section than Wabash soils.

54—Zook silty clay loam, 0 to 2 percent slopes. This soil is on low, flat flood plains in areas that are typically 15 to 30 acres in size and irregular in shape. It has the profile described as representative of the series. The content of organic matter in the plow layer is 4 to 5 percent.

Included with this soil in mapping are small areas of Wabash and Colo soils.

This soil is well suited to row crops if wetness is controlled, and it is used mostly for row crops. Wetness and flooding are the main limitations. The surface layer dries slowly after rain, therefore tillage operations are delayed. More power is needed to till this soil than most other bottom-land soils. Capability unit IIw-1.

54+—Zook silt loam, overwash, 0 to 2 percent slopes. This soil is on low, flat flood plains. Overflow from streams and drainage ditches has deposited light-colored sediment on this soil. The areas are typically 10 to 20 acres in size and are irregular in shape.

This soil has a profile similar to the one described as representative of the series, except that 6 to 15 inches of very dark grayish brown to dark grayish brown silty material overlies the original black surface layer. The plow layer is 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of Wabash and Colo soils.

This soil is well suited to row crops if wetness and flooding are controlled. Because the overwash is silt loam, this soil dries faster than the other Zook soils. This soil requires less power to till than other Zook soils, and this soil generally is in better tilth. Capability unit IIw-1.

Use and management of the soils

The soil survey is a detailed analysis and evaluation of the most basic resource of the survey area—the soil. It may be used to fit the use of the land, including urbanization, to the limitations and potentials of the natural resources and the environment and to help avoid soil-related failures in uses of the land.

While a soil survey is in progress, soil scientists, conservationists, engineers, and others keep extensive notes, not only about the nature of the soils but also about unique aspects of behavior of these soils in the field and at construction sites. These notes include observations of erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic systems, and other factors relating to the kinds of soil and their productivity, potentials, and limitations under various uses and management. In this way field experience incorporated with measured data on soil properties and performance is used as a basis for predicting soil behavior.

Information in this section will be useful in applying basic facts about the soils to plans and decisions for use and management of soils for crops and pasture, woodland, and many nonfarm uses including building sites, highways and other transportation systems, sanitary facilities, parks and other recreational developments, and wildlife habitat. From the data presented, the potential of each soil for specified land uses may be determined, soil limitations to these land uses may be identified, and costly failures in homes and other structures, due to unfavorable soil properties, may be avoided. A site can be selected where the soil properties are favorable, or practices can be planned that will overcome the soil limitations.

Cropland and pasture

In Page County about 182,147 acres, or about 52.3 percent of the county, is used for crops. About 93,699 acres, or 27.3 percent, is used for pasture. Much of the approximately 11,000 acres that is wooded is also used for pasture and is included in the pasture acreage.

Corn, soybeans, legumes, and legume-grass hay are the main crops. Oats, sorghums, and popcorn are also grown, but the acreage is smaller. Approximately 2,000 acres is used for nursery stock. Conifers of all types, fruit trees, hardwood trees, shrubs, a variety of bulbs, and many kinds of flower and vegetable seeds are grown.

Many pastures are permanent bluegrass. Some have been renovated, and plants such as birdsfoot trefoil have been introduced. Grasses such as bromegrass and orchardgrass or grass-legume mixtures such as alfalfa-bromegrass are pastured.

Many soils in the county are subject to erosion. The erosion hazard is most severe on Adair, Gara, Ladoga, Marshall, Sharpsburg, and Shelby soils because runoff is rapid on the steeper slopes. The gently sloping to moderately sloping Judson soils are susceptible to erosion. On Adair, Gara, and Shelby soils, gullying is a serious hazard, particularly on the steeper slopes. If not controlled, the gullies rapidly work their way upslope.

Graded, level, and grassed back-slope terraces and tillage on the contour are commonly used for erosion control. Gully control structures, farm ponds, tile terrace outlets, and grassed waterways help control gullying in watercourses. Farm ponds provide water for livestock and recreation.

Wetness is a limitation on some of the bottom-land soils. Bremer, Colo, Judson, Wabash, and Zook soils are subject to wetness because of a high water table, runoff from adjacent uplands, or both. Wetness is a problem because these soils have moderately slow or slow permeability in the subsoil.

Diversion terraces are used to divert runoff from bottom-land soils. Tile drainage is used to remove excess water from Bremer and Colo soils. Surface drainage ditches are used on Zook and Wabash soils because the fine texture and high water table make tile drainage impractical or inefficient. Shallow field ditches and land grading are used in places to remove water that tends to stand on the surface.

Flooding is a hazard on Nodaway soils. Flooding was a serious hazard, but most of the streams have been straightened, and levees have been built in some places so that flooding is less frequent.

Capability grouping

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

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

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

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, 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 very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.
- Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to pasture, range, woodland, or wildlife habitat.
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or 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, 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; these soils, however, have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass or kind of limitation; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Page County are described.

Capability unit I-1

This unit consists of nearly level, well drained and moderately well drained Marshall and Sharpsburg soils. These soils are silty clay loam throughout.

The available water capacity is high. Permeability is moderate or moderately slow. The organic-matter content is moderate.

These soils are suited to corn, soybeans, and other row crops. They are also suited to small grain, alfalfa, pasture, and other less intensive uses.

Capability unit I-2

This unit consists of nearly level, somewhat poorly drained Macksburg, Minden, and Nevin soils. These soils have a surface layer of silty clay loam and a subsoil of silty clay loam or light silty clay.

The available water capacity is high. Permeability is moderate or moderately slow. The organic-matter content is high.

These soils are suited to corn, soybeans, and other row crops. They are also suited to small grain, alfalfa, pasture, and other less intensive uses.

Capability unit I-3

The only soil in this unit is Kennebec silt loam, 0 to 2 percent slopes. It is nearly level and moderately well drained. This soil is silt loam or light silty clay loam throughout.

The available water capacity is high. Permeability is moderate, and the organic-matter content is high.

Areas of this soil near stream channels are subject to infrequent flooding. Flooding usually occurs for short periods before crops are planted.

This soil is suited to corn, soybeans, and other row crops. It is also suited to small grain, hay, pasture, and other less intensive uses.

Capability unit IIe-1

This unit consists of gently sloping, well drained or moderately well drained Judson, Ladoga, Marshall, Sharpsburg, and Olmitz soils. Judson, Marshall, and Sharpsburg soils are silty clay loam throughout. Ladoga soils have a surface layer of silt loam. Their subsoil is silty clay loam but ranges to light silty clay. Olmitz soils have a loam surface layer and a clay loam subsoil.

The available water capacity is high. Permeability is moderate or moderately slow. The organic-matter content is moderate to high in uneroded areas.

Water erosion is a slight hazard. Contour farming or terraces help to control erosion. Diversion terraces can keep runoff from Judson and Olmitz soils.

These soils are suited to corn, soybeans, and other row crops. They are also suited to small grain, hay, pasture, and other less intensive uses.

Capability unit IIw-1

This unit consists of nearly level or gently sloping, poorly drained Bremer, Colo, Judson, Winterset, and Zook soils. These soils are silty clay loam throughout, except for Zook and Winterset soils which have a silty clay subsoil.

The available water capacity is high. Permeability is moderate, moderately slow, or slow. The organic-matter content is high.

Wetness is a limitation, and artificial drainage is needed to maintain productivity. Tile drains can control wetness, although Zook soils may require surface drainage.

These soils are suited to corn, soybeans, and other row crops. They are also suited to small grain, pasture, and other less intensive uses.

Capability unit IIw-2

The only soil in this unit is Nodaway silt loam, 0 to 2 percent slopes. It is nearly level and moderately well drained. This soil is silt loam throughout.

The available water capacity is high. Permeability is moderate, and the organic-matter content is low.

Wetness is a hazard because this soil is subject to flooding for short periods in years when rainfall is excessive. But the flooding usually occurs early in spring before crops are planted.

If this soil is protected from flooding, it is suited to corn, soybeans, and other row crops. It is also suited to small grain, alfalfa, pasture, and other less intensive uses.

Capability unit IIIe-1

This unit consists of moderately sloping Olmitz soils and moderately sloping to strongly sloping Ladoga, Marshall, Northboro, Sharpsburg, and Shelby soils. These soils have a surface layer of silt loam, silty clay loam, clay loam, or silty clay. The soils are well drained or moderately well drained.

The available water capacity is high. Permeability is moderate or moderately slow. The organic-matter content is moderate to high in uneroded areas.

Erosion is the main hazard, particularly on the steeper slopes. Terraces, contour farming, or mulch tillage help control erosion (fig. 10). Grassed water-

Figure 10.—**Graded terraces predominantly on strongly sloping Sharpsburg soils, which are in capability unit IIIe–1.**

ways or tile terrace outlets help prevent ditches and gullies from forming (fig. 11).

If erosion is controlled, these soils are moderately suited to corn, soybeans, and other row crops. They are well suited to small grain, hay, and pasture.

Capability unit IIIe–2

This unit consists of moderately sloping, moderately well drained or somewhat poorly drained Adair and Mayberry soils. These soils have a silty clay loam or clay loam surface layer and a silty clay subsoil.

The available water capacity is high. Permeability is slow, and the organic-matter content is moderate in uneroded areas.

Erosion is the main hazard. Because the subsoil is fine textured, the loss of the surface layer severely affects productivity on these soils. The slow permeability of these soils can result in seepy areas in the more permeable soils that are immediately upslope. These seepy areas can affect tillage time and limit the yield.

Terraces and contour farming on upslope soils help control erosion. Overgrazing should be avoided to maintain a close ground cover. Tile terrace outlets and erosion control structures help prevent ditches and gullies from forming. Seepy areas can be eliminated by an interceptor tile system in the upslope soils.

If erosion is controlled, these soils are moderately suited to corn, soybeans, and other row crops. They are well suited to hay and pasture.

Capability unit IIIw–1

This unit consists of Wabash soils. These soils are nearly level and are very poorly drained. They have a surface layer of silt loam, silty clay loam, or silty clay and a subsoil of silty clay.

The available water capacity is moderate. Permeability is very slow, and the organic-matter content is high.

Wetness limits the use of these soils for cropland. Runoff is slow, and these soils have a seasonal high water table. They warm up slowly in the spring, and fieldwork is delayed by wetness. Most of the soils are difficult to work and tend to become cloddy if worked when too damp. Surface drains can remove excess water. Tile drains are not effective because permeability is very slow.

If adequately drained, these soils are moderately suited to corn, soybeans, and other row crops. They are also suited to small grain and pasture.

Capability unit IVe–1

This unit consists of strongly sloping Gara, Shelby, and Adair soils and moderately steep Shelby soils. These soils are well drained to somewhat poorly drained. They have a surface layer of loam or clay loam and a subsoil of clay loam or silty clay.

The available water capacity is high. Permeability is moderately slow to slow. The organic-matter content is moderate to moderately low in uneroded areas; it is low in Gara soils.

Erosion is the main hazard. If erosion is not controlled, uncrossable gullies can form and rocks may be exposed, making tillage difficult. Terraces can control erosion, but sometimes revegetating the channels is difficult. Crop rotation helps control erosion. Grassed

Figure 11.—**Terraces on Marshall soils, which are in capability unit IIIe–1.**

waterways and tile terrace outlets help prevent ditches and gullies from forming.

These soils are well suited to hay and pasture. If erosion is not controlled, they are poorly suited to row crops and small grain during part of the year.

Capability unit IVe–2

This unit consists of strongly sloping, moderately well drained or somewhat poorly drained Adair and Mayberry soils. These soils have a surface layer of silty clay loam or clay loam and a subsoil of silty clay.

The available water capacity is high. Permeability is slow, and the organic-matter content is moderate in uneroded areas.

Erosion is the main hazard. Because these soils have slow permeability, runoff is rapid, and erosion is accelerated. The subsoil is fine textured and unfavorable to most cultivated crops; therefore, the loss of the surface layer severely affects productivity. Seepy areas, in some places, affect tillage. Terraces and a crop rotation system can help control erosion, but sometimes establishing vegetation is difficult on the exposed subsoil in the channel. Overgrazing should be avoided in order to maintain a close ground cover. Tile terrace outlets and erosion control structures can prevent ditches and gullies from forming. An interceptor tile system on the upslope soils can eliminate seep areas.

If erosion is not controlled, these soils are poorly suited to corn, soybeans, and other row crops. They are better suited to hay and pasture.

Capability unit Vw–1

This unit consists of Alluvial land, sandy, which is nearly level and excessively drained. The texture is variable but is generally sand or a mixture of silt and sand.

The available water capacity is low. Permeability is rapid, and the organic-matter content is low.

Flooding is the main hazard. Because the areas of Alluvial land are near stream channels, it is difficult and generally not economical to protect them from overflow. Because of the sandy texture and rapid permeability, droughtiness is a limitation that directly affects productivity.

Alluvial land, sandy, generally is not suited to cultivated crops. If it is irrigated and protected from flooding, it has potential for agricultural use or less intensive uses.

Capability unit VIe–1

This unit consists of moderately steep Gara, Adair, and Shelby soils and steep Shelby soils. These soils are well drained to somewhat poorly drained. They have a surface layer of loam or clay loam and a subsoil of clay loam or silty clay.

The available water capacity is high. Permeability is moderately slow to slow. The organic-matter content is low to moderate.

Erosion is the main hazard. Because of the steep slopes, runoff is rapid, and erosion is accelerated. Runoff can be controlled by terraces. Maintaining a good vegetative cover can help control erosion. Farm ponds and erosion control structures help prevent ditches and gullies from forming.

If erosion is controlled, these soils are suited to pasture and hay. They generally are not suited to row crops and small grain.

Capability unit VIs–1

The only soil in this unit is Sparta loamy fine sand, 5 to 14 percent slopes. It is strongly and moderately sloping and is excessively drained. It has a surface layer of loamy fine sand. The subsoil is sand.

The available water capacity is very low. Permeability is very rapid, and the organic-matter content is low.

Droughtiness is a limitation on this soil. This soil is easily tilled but dries rapidly. When dry, it is susceptible to soil blowing. Increasing the content of organic matter helps prevent soil blowing and conserves moisture.

This soil is generally not suited to row crops. It is suited to pasture and hay when rainfall is normal or above normal.

Capability unit VIIe–1

This unit consists of well drained to moderately well drained, steep, moderately eroded Gara soils on upland side slopes. In most areas the surface layer is friable loam. In severely eroded areas it is light colored, firm clay loam that is hard when dry. The subsoil is moderately fine textured and mostly firm clay loam.

The available water capacity is high. Permeability is moderately slow, and the organic-matter content of the surface layer is moderately low.

Runoff is very rapid because of the steep slopes. Gullies form rapidly. These soils have properties that are favorable for deep root development by grasses and trees.

These soils are not suited to use as cropland and have severe limitations for use as pasture because of the steep slopes. They are suited to woodland use and for wildlife habitat.

Areas range in size from small to large and are mainly in pasture, timbered pasture, or woodland. Mowing and seeding the more productive grasses and legumes is beneficial in areas not too steep for the use of farm machinery.

Selective cutting and removing undesirable trees and brush improve the yield of woodland products. Many timbered areas that are presently used as pasture would produce more woodland products if livestock were fenced out and if good woodland management were practiced. These soils have properties favorable for ponds, gully control, water storage, wildlife, and recreation areas.

Yields per acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 2. In any given year, yields may be higher or lower then those indicated in the table because of variations in rainfall and other climatic factors. In table 2, absence of an estimated yield indicates that the soil is not suited to the crop or that the crop is not commonly grown on the soil or that a given crop is not commonly irrigated.

The estimated yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Results of field trials and demonstrations and available yield data from nearby counties were also considered.

The yields were estimated assuming that the latest soil and crop management practices were used. Hay and pasture yields were estimated for varieties of grasses and legumes suited to the soil. A few farmers may be obtaining average yields higher than those shown in table 2.

The management needed to achieve the indicated yields of the various crops depends on the kind of soil and the crop. Such management provides drainage, erosion control, and protection from flooding; proper planting and seeding rates; suitable high-yielding crop varieties; appropriate tillage practices, including time of tillage and seedbed preparation and tilling when soil moisture is favorable; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; harvesting crops with the smallest possible loss; and timeliness of all fieldwork.

Crops other than those shown in table 2 are grown in the survey area, but estimated yields are not included because the acreage of these crops is small. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide information about the productivity and management concerns of the soils for these crops.

Woodland

About 11,000 acres of Page County is wooded. Most of the woodland is in the uplands near the Nodaway and East Nodaway Rivers and their larger tributaries. Most farms have landscape and windbreak plantings of trees and shrubs, and few have small woodlots.

Most wooded areas are grazed and produce little timber that can be marketed. Very steep woodland areas produce only a limited amount of pasture and generally provide little more than shade for livestock and habitat for wildlife.

The acreage of woodland in the county has not significantly changed in recent years. Some areas have been converted to cropland, mainly in the bottom lands. The woodlots and buildings on many vacant farmsteads have been removed, and the areas are used for crops. In recent years, Dutch Elm disease has killed off much of the American Elm stands.

Farmers in Page County are concerned mainly with planting trees for windbreaks rather than for timber. The demand for trees for lumber is small, and the quality of timber that is produced is poor. Several agencies in Iowa have programs to assist woodland owners in improving the quality of their products and to inform them about basic marketing practices. The Soil Conservation Service assists landowners and operators in determining the best land use. Foresters employed by the Iowa State Conservation Commission assist in planning the management of woodland.

Types of woodland

There are mainly two types of woodland in Page County, the oak-hickory type and the soft maple-cottonwood-willow type.

TABLE 2.—*Yields per acre of crops and pasture*

[Yields are those that can be expected under a high level of management. The estimates were made in 1974. Dashes indicate that the crop is seldom grown or is not suitable]

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* [1]	*AUM* [1]
Judson:						
8B	124	47	93	5.2	8.6	4.2
Marshall:						
9B, T9B	107	41	61	4.0	6.7	3.8
9B2	105	40	60	4.0	6.6	3.8
9C	102	39	58	3.9	6.5	3.5
9C2	99	38	56	3.8	6.3	3.3
T9	109	41	62	4.1	6.9	3.8
Colo:						
[2] 11B	109	41	82	4.4	6.4	4.2
Shelby:						
24D	84	32	46	3.5	5.0	3.3
24D2	81	31	44	3.4	4.9	3.3
24E	69	26	38	2.9	4.1	2.3
24E2	66	25	36	2.7	4.0	2.1
24F2	---	---	---	---	---	1.7
Sparta:						
41D	---	---	---	---	---	2.0
Bremer:						
43	106	40	58	4.5	5.7	4.0
Zook:						
54	96	36	72	4.0	4.0	4.0
54+	101	38	75	4.2	4.4	4.4
Ladoga:						
76B	113	43	62	4.7	7.8	4.3
76C	108	41	59	4.5	7.5	4.0
76C2	105	40	57	4.4	7.3	3.9
76D	99	38	54	4.2	7.0	3.8
76D2	96	36	53	4.0	6.7	3.7
Nevin:						
88	114	43	63	4.8	8.0	4.0
Shelby:						
[2] 93D	74	28	40	3.1	4.3	2.7
[2] 93D2	69	26	38	2.9	4.0	2.7
[2] 93E2	---	---	---	---	---	1.1
Marshall:						
99C	102	39	58	3.9	6.5	3.5
99C2	99	38	56	3.8	6.3	3.3
99D	93	35	53	3.5	5.8	3.3
99D2	90	34	51	3.4	5.5	3.0
Colo:						
133	104	40	78	4.2	5.5	4.2
133+	109	42	82	4.3	5.8	4.2
Wabash:						
172	65	32	---	2.0	---	---
Gara						
179D	78	30	43	3.3	4.7	2.7
179D2	75	28	41	3.1	4.5	2.5
179E2	---	---	---	2.2	---	1.5
179F2	---	---	---	1.2	---	1.3
179G2	---	---	---	1.0	---	1.0

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Ton*	*AUM* [1]	*AUM* [1]
Adair:						
192C	73	28	40	3.1	4.0	2.7
192C2	65	25	36	2.7	3.5	2.3
192D	62	23	34	2.6	3.3	2.0
192D2	54	20	30	2.3	2.9	1.9
Kennebec:						
212	121	46	80	5.1	7.1	4.2
Nodaway:						
220	110	42	60	4.6	6.5	4.0
Wabash:						
248, 248+	80	35	------------	2.5	------------	------------
Olmitz:						
273B	100	38	55	4.2	6.0	3.9
273C	95	36	52	4.0	5.7	3.7
Minden:						
T299	115	44	66	4.4	7.3	4.3
Macksburg:						
T368	121	46	67	5.1	8.4	4.5
Winterset:						
T369	117	44	64	4.9	8.2	4.3
Sharpsburg:						
370	115	44	63	4.8	8.0	4.2
370B, T370B	113	43	62	4.7	7.8	4.2
370B2	110	42	61	4.6	7.5	4.1
370C, T370C	108	41	59	4.5	7.3	4.1
370C2	108	40	58	4.4	7.0	4.0
370D	99	38	54	4.2	6.8	3.9
370D2	96	36	53	4.0	6.7	3.8
Mayberry:						
692C2	60	23	33	2.5	3.0	2.1
692D	59	21	31	2.3	2.8	2.0
692D2	51	19	28	2.0	2.3	1.8
Alluvial land, sandy:						
715	------------	------------	------------	------------	------------	2.0
Northboro:						
751C	100	38	57	3.8	6.3	3.7
751C2	97	37	55	3.6	5.9	3.5
751D	91	34	52	3.4	5.5	3.3
751D2	88	33	50	3.3	5.2	3.2

[1] Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 30 days.

[2] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

The oak-hickory type is on the uplands, mainly near the major streams. In these areas the major soils are Gara and Ladoga soils, which are deep and gently sloping to very steep and have a high available water capacity. The major stands are oak and hickory. Other stands include elm, basswood, hackberry, and green ash.

The soft maple-cottonwood-willow type is on low benches and nearly level flood plains. In these areas the major soils are Kennebec, Nodaway, Colo, and Judson soils. These soils are deep and nearly level and have a high available water capacity. The major stands are soft maple, cottonwood, and willow. Other stands include elm, various kinds of oak, box elder, green ash, and black walnut. The willow and cottonwood trees generally are near streams in areas that are subject to overflow and prolonged wetness.

When the county was settled, landscape and windbreak plantings were established. These plantings include spruce and various kinds of pine, cedar, and fir.

Table 3 contains information useful to woodland owners or forest managers planning the use of soils for wood crops. Mapping unit symbols for soils suitable for wood crops are listed, and the ordination symbol for each soil is given. All soils bearing the same ordination symbol require the same general kind of woodland management and have about the same potential productivity.

The first part of the symbol, a number, indicates the potential productivity of the soils for important trees. The number 1 indicates very high productivity; 2, high; 3, moderately high; 4, moderate; and 5, low. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *x* indicates stoniness or rockiness; *w*, excessive water in or on the soil; *t*, toxic substances in the soil; *d*, sandy texture; *f*, high content of coarse fragments in the soil profile; and *r*, steep slopes. The letter *o* indicates no significant limitations or restrictions. If a soil has more than one limitation, priority in placing the soil into a limitation class is in the following order: x, w, t, d, c, s, f, and r.

In table 3 the soils are also rated for a number of factors to be considered in management. *Slight, moderate,* and *severe* are used to indicate the degree of major soil limitations.

Ratings of the *erosion hazard* indicate the risk of loss of soil in well managed woodland. The risk is *slight* if the expected soil loss is small; *moderate,* if some measures are needed to control erosion during logging and road construction; and *severe,* if intensive management or special equipment and methods are needed to prevent excessive loss of soil.

Ratings of *equipment limitation* reflect the characteristics and conditions of the soil that restrict use of the equipment generally needed in woodland management or harvesting. A rating of *slight* indicates that use of equipment is not limited to a particular kind of equipment or time of year; *moderate* indicates a short seasonal limitation or a need for some modification in management or equipment; and *severe* indicates a seasonal limitation, a need for special equipment or management, or a hazard in the use of equipment.

Seedling mortality ratings indicate the degree that the soil affects expected mortality of planted tree seedlings. Plant competition is not considered in the ratings. Seedlings from good planting stock that are properly planted during a period of sufficient rainfall are rated. A rating of *slight* indicates that the expected mortality of the planted seedlings is less than 25 percent; *moderate,* 25 to 50 percent; and *severe,* more than 50 percent.

Ratings of *plant competition* indicate the degree to which undesirable plants are expected to invade or grow if openings are made in the tree canopy. The invading plants compete with native plants or planted seedlings by impeding or preventing their growth. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; and *severe* indicates that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed for the control of undesirable plants.

The *potential productivity* of merchantable or *important trees* on a soil is expressed as a *site index.* This index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even-aged, unmanaged stands. Important trees are those that woodland managers generally favor in intermediate or improvement cuttings. They are selected on the basis of growth rate, quality, value, and marketability.

Trees to plant are those that are suitable for commercial wood production and that are suited to the soils.

Engineering

This section provides information about the use of soils for building sites, sanitary facilities, construction materials, and water management. Among those who can benefit from this section are engineers, landowners, community planners, town and city managers, land developers, builders, contractors, farmers, and ranchers.

The ratings in the engineering tables are based on test data and estimated data in the "Soil properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service using known relationships between the soil properties and the behavior of soils in various engineering uses.

Among the soil properties and site conditions identified by the soil survey and used in determining the ratings in this section are grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock that is within 5 or 6 feet of the surface, soil wetness, depth to a seasonal water table, slope, likelihood of flooding, natural soil structure or aggregation, in-place soil density, and geologic origin of the soil material. Where pertinent, data about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of absorbed cations were also considered.

On the basis of information assembled about soil properties, ranges of values can be estimated for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, shear strength, compressibility, slope stability, and other factors of expected soil behavior in engineering uses. As appropriate, these values can be applied to each major horizon of each soil or to the entire profile.

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works. The ranges of values can be used to (1) select potential residential, commercial, industrial, and recreational areas; (2) make preliminary estimates pertinent to construction in a particular area; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for location of sanitary landfills, onsite sewage disposal systems, and other waste disposal facilities; (5) plan detailed onsite investigations of soils and geology; (6) find sources of gravel, sand, clay, and topsoil; (7) plan farm drainage systems, irrigation systems, ponds, terraces, and other struc-

TABLE 3.—*Woodland management and productivity*

[Only the soils suitable for production of commercial trees are listed in this table. Dashes in a column indicate that the information was not available]

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Management concerns: Equipment limitation	Management concerns: Seedling mortality	Management concerns: Plant competition	Potential productivity: Important trees	Potential productivity: Site index	Trees to plant
Judson:								
8B	2o	Slight	Slight	Slight	Moderate	Black walnut White oak Northern red oak	73 --- ---	Black walnut, eastern cottonwood, green ash.
Colo:								
[1] 11B:								
Colo part.								
Judson part	2o	Slight	Slight	Slight	Moderate	Black walnut White oak Northern red oak	73 --- ---	Black walnut, eastern cottonwood, green ash.
Bremer:								
43	3w	Slight	Severe	Moderate	Severe	Eastern cottonwood. Silver maple	90 80	American sycamore, hackberry, green ash, eastern cottonwood, silver maple, northern white-cedar.
Ladoga:								
76B, 76C, 76C2, 76D, 76D2	2o	Slight	Slight	Slight	Moderate	White oak Northern red oak	65 65	Eastern white pine, red pine, Norway spruce, scotch pine, European larch, eastern redcedar, sugar maple, white spruce.
Wabash:								
172	4w	Slight	Moderate	Severe	Severe	Pin oak	75	Pin oak, pecan, eastern cottonwood.
Gara:								
179E2, 179F2, 179G2	3r	Moderate	Moderate	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, scotch pine.
Kennebec:								
212	2o	Slight	Slight	Slight	Moderate	Black walnut Bur oak Hackberry Green ash Eastern cottonwood.	79 63 --- --- ---	Black walnut, bur oak, hackberry, green ash, eastern cottonwood, American sycamore.
Nodaway:								
220	2o	Slight	Slight	Slight	Moderate	White oak	65	Eastern white pine, red pine, Norway spruce, scotch pine, white spruce, European larch, black walnut, sugar maple.

TABLE 3.—*Woodland management and productivity*—Continued

Soil name and map symbol	Ordination symbol	Management concerns				Potential productivity		Trees to plant
		Erosion hazard	Equipment limitation	Seedling mortality	Plant competition	Important trees	Site index	
Wabash:								
248, 248+	4w	Slight	Moderate	Moderate	Severe	Pin oak	75	Pin oak, pecan, eastern cottonwood.
Sharpsburg:								
370, 370B, 370B2, 370C, 370C2, 370D, 370D2, T370B, T370C	4o	Slight	Slight	Slight	Slight	Black oak Black walnut White oak Hackberry Green ash	60 60 --- --- ---	Black walnut, hackberry, green ash.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

tures for soil and water conservation; (8) relate performance of structures already built to the properties of the kinds of soil on which they are built so that performance of similar structures on the same or a similar soil in other locations can be predicted; and (9) predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. First, the data are generally not presented for soil material below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations and testing.

The information is presented mainly in tables. Table 4 shows, for each kind of soil, the degree and kind of limitations for building site development; table 5, for sanitary facilities; and table 7, for water management. Table 6 shows the suitability of each kind of soil as a source of construction materials.

The information in the tables, along with the soil map, soil descriptions, and other data provided in this survey, can be used to make additional interpretations and construct interpretive maps for specific uses of land.

Some of the terms used in this soil survey have a special meaning in soil science. Many of these terms are defined in the Glossary.

Building site development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets are indicated in table 4. A *slight* limitation indicates that soil properties are favorable for the specified use and that any limitation is minor and easily overcome. A *moderate* limitation indicates that soil properties and site features are not favorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates one or more soil properties or site features are so unfavorable or difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils rated severe, such costly measures may not be feasible.

Shallow excavations are made for pipelines, sewerlines, communications and power transmission lines, basements, open ditches, and cemeteries. Such digging or trenching is influenced by the soil wetness caused by a seasonal high water table; the texture and consistence of soils; the tendency of soils to cave in or slough; and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by slope of the soil and the probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

In the soil series descriptions, the consistence of each soil horizon is given, and the presence of very firm or extremely firm horizons, usually difficult to excavate, is indicated.

Dwellings and small commercial buildings referred to in table 4 are built on undisturbed soil and have foundation loads of a dwelling more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable that cracking or subsidence from settling or shear failure of the foundation does not occur. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and in-place density, potential frost action, soil wetness, and depth to a seasonal high water table were also considered. Soil wetness and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and the large stones in or on the soil are also important considerations in

TABLE 4.—*Building site development*

["Shrink-swell" and some of the other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Judson:					
8B	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
Marshall:					
9B, 9B2, T9, T9B	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.
9C, 9C2	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.
Colo:					
[1] 11B:					
Colo part	Severe: wetness, floods.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, low strength, frost action.
Judson part	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
Shelby:					
24D, 24D2	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
24E, 24E2, 24F2	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Sparta:					
41D	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.
Bremer:					
43	Severe: wetness	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.
Zook:					
54, 54+	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength.
Ladoga:					
76B	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action.
76C, 76C2	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: frost action.
76D, 76D2	Moderate: slope, wetness.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: shrink-swell, slope.	Severe: frost action.
Nevin:					
88	Severe: wetness	Severe: floods	Severe: floods	Severe: floods	Severe: frost action, low strength.
Shelby:					
[1] 93D:					
Shelby part	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
Adair part	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.

TABLE 4.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
[1] 93D2:					
Shelby part	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
Adair part	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
[1] 93E2:					
Shelby part	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Adair part	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Marshall:					
99C, 99C2	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.
99D, 99D2	Moderate: slope	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: slope	Severe: low strength, frost action.
Colo:					
133, 133+	Severe: wetness, floods.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, low strength, frost action.
Wabash:					
172	Severe: wetness, floods, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.
Gara:					
179D, 179D2	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
179E2, 179F2, 179G2	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Adair:					
192C, 192C2, 192D, 192D2	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Kennebec:					
212	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action, low strength.
Nodaway:					
220	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action.
Wabash:					
248, 248+	Severe: wetness, floods, too clayey.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.	Severe: wetness, floods, shrink-swell.
Olmitz:					
273B	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.
273C	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.

TABLE 4.—*Building site development*—Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
Minden:					
T299	Moderate: wetness.	Moderate: shrink-swell, wetness, low strength.	Severe: wetness	Moderate: shrink-swell, wetness, low strength.	Severe: frost action, low strength.
Macksburg:					
T368	Severe: wetness	Moderate: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Moderate: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength, frost action.
Winterset:					
T369	Severe: wetness, too clayey.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.
Sharpsburg:					
370, 370B, 370B2, 370C, 370C2, T370B, T370C	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
370D, 370D2	Moderate: slope	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, slope.	Severe: shrink-swell, low strength.
Mayberry:					
692C2, 692D, 692D2	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, frost action, low strength.
Alluvial land, sandy:					
715	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Northboro:					
751C, 751C2	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action.
751D, 751D2	Moderate: wetness, slope.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: frost action.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

the choice of sites for these structures and were considered in determining the ratings. Susceptibility to flooding is a serious limitation.

Local roads and streets referred to in table 4 have an all-weather surface that can carry light to medium traffic all year. They consist of a subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with soil material at hand, and most cuts and fills are less than 6 feet deep.

The load supporting capacity and the stability of the soil as well as the quantity and workability of fill material available are important in design and construction of roads and streets. The AASHTO and Unified classifications of soil, soil texture, density, shrink-swell potential, and frost action potential are indicators of the traffic-supporting capacity used in making the ratings. Soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones affect stability and ease of excavation.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities and in identifying limiting soil properties and site features to be considered in design and installation. Also, those soil properties that affect ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 5 shows the degree and kind of limitations of each soil for such uses and for use of the soil as daily cover for landfills.

If the degree of soil limitation is expressed as *slight*, soils are generally favorable for the specified use and

TABLE 5.—*Sanitary facilities*

["Percs slowly" and other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoons	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Judson:					
8B	Slight	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
Marshall:					
9B, 9B2, T9B	Slight	Moderate: seepage, slope.	Slight	Slight	Fair: too clayey.
9C, 9C2	Slight	Severe: slope	Slight	Slight	Fair: too clayey.
T9	Slight	Moderate: seepage, excess humus.	Slight	Slight	Fair: too clayey.
Colo:					
[1] 11B:					
Colo part	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Judson part	Slight	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
Shelby:					
24D, 24D2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
24E, 24E2, 24F2	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope.
Sparta:					
41D	Moderate: slope	Severe: seepage, slope.	Severe: seepage	Severe: seepage	Fair: too sandy, slope.
Bremer:					
43	Severe: percs slowly.	Severe: wetness, excess humus.	Severe: wetness, excess humus.	Severe: wetness	Poor: wetness.
Zook:					
54, 54+	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, too clayey, floods.	Severe: wetness, floods.	Poor: wetness, too clayey.
Ladoga:					
76B	Severe: percs slowly.	Moderate: slope	Moderate: too clayey.	Slight	Fair: too clayey.
76C, 76C2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
76D, 76D2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
Nevin:					
88	Severe: wetness, percs slowly.	Moderate: seepage, wetness, excess humus.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
Shelby:					
[1] 93D:					
Shelby part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
Adair part	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Moderate: slope	Poor: area reclaim.
[1] 93D2:					
Shelby part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.

TABLE 5.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoons	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Adair part	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Moderate: slope	Poor: area reclaim.
[1] 93E2: Shelby part	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope.
Adair part	Severe: percs slowly, slope.	Severe: slope	Severe: wetness, too clayey.	Severe: slope	Poor: area reclaim.
Marshall: 99C, 99C2	Slight	Severe: slope	Slight	Slight	Fair: too clayey.
99D, 99D2	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: too clayey, slope.
Colo: 133, 133+	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Wabash: 172	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness, too clayey.
Gara: 179D, 179D2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
179E2, 179F2	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope, area reclaim.
179G2	Severe: percs slowly, slope.	Severe: slope	Severe: slope	Severe: slope	Poor: slope, area reclaim.
Adair: 192C, 192C2	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Slight	Poor: area reclaim.
192D, 192D2	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Moderate: slope	Poor: area reclaim.
Kennebec: 212	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Good.
Nodaway: 220	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
Wabash: 248, 248+	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness, too clayey.
Olmitz: 273B	Moderate: percs slowly.	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: thin layer.
273C	Moderate: slope	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: thin layer.
Minden: T299	Severe: wetness	Moderate: seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
Macksburg: T368	Severe: percs slowly, wetness.	Moderate: wetness, excess humus.	Moderate: wetness.	Moderate: wetness.	Fair: too clayey.

TABLE 5.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoons	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Winterset:					
T369	Severe: percs slowly, wetness.	Moderate: wetness, excess humus.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Sharpsburg:					
370	Severe: percs slowly.	Slight	Moderate: too clayey.	Slight	Fair: too clayey.
370B, 370B2, T370B	Severe: percs slowly.	Moderate: slope	Moderate: too clayey.	Slight	Fair: too clayey.
370C, 370C2, T370C	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
370D, 370D2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: slope, too clayey.
Mayberry:					
692C2	Severe: percs slowly.	Severe: slope	Severe: percs slowly.	Slight	Poor: too clayey.
692D, 692D2	Severe: percs slowly.	Severe: slope	Severe: percs slowly.	Moderate: slope	Poor: too clayey.
Alluvial land, sandy:					
715	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Poor: wetness.
Northboro:					
751C, 751C2	Severe: percs slowly.	Severe: slope	Slight	Slight	Good.
751D, 751D2	Severe: percs slowly.	Severe: slope	Slight	Moderate: slope	Fair: slope.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

limitations are minor and easily overcome; if *moderate,* soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe,* soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance is required. Soil suitability is rated by the terms *good, fair,* and *poor,* which mean about the same as slight, moderate, and severe.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. The soil properties and site features considered are those that affect the absorption of the effluent and those that affect the construction of the system.

Properties and features that affect absorption of the effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and shallowness to bedrock interfere with installation. Excessive slope can cause lateral seepage and surfacing of the effluent. Also, soil erosion and soil slippage are hazards if absorption fields are installed in sloping soils.

In some soils, loose sand and gravel or fractured bedrock is less than 4 feet below the tile lines. In these soils the absorption field does not adequately filter the effluent, and ground water in the area can be contaminated.

Percolation tests are performed to determine the absorptive capacity of the soil and its suitability for use as septic tank absorption fields. These tests should be performed during the season when the water table is highest and the soil is at minimum absorptive capacity.

On many of the soils that have moderate or severe limitations for use as septic tank absorption fields, a system to lower the seasonal water table can be installed or the size of the absorption field can be increased so that performance is satisfactory.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons have a nearly level floor surrounded by cut slopes or embankments of compacted, nearly impervious soil material. They generally are designed to hold sewage within a depth of 2 to 5 feet. Impervious soil at least 4 feet thick for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Soils that have a very high content of organic matter and those that have stones and boulders are not suitable. Unless the soil has very slow permeability, contamination of ground water is a hazard where the seasonal high water table is above the level of the lagoon floor. Where the water table is seasonally high, seepage of ground water into the lagoon can seriously reduce the lagoon's capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the suitability of sites for sewage lagoons or the cost of construction. Shear strength and permeability of compacted soil material affect the performance of embankments.

Sanitary landfill is a method of disposing of solid waste by placing refuse in successive layers either in excavated trenches or on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil material. Landfill areas are subject to heavy vehicular traffic. Ease of excavation, risk of polluting ground water, and trafficability affect the suitability of a soil for this use. The best soils have a loamy or silty texture, have moderate to slow permeability, are deep to a seasonal water table and to bedrock, are free of large stones and boulders, and are not subject to flooding. In areas where the seasonal water table is high, excavating trenches is a problem and water seeps into and fills the trenches. Also, seepage into the refuse increases the risk of ground water pollution. Clayey soils are likely to be sticky and difficult to spread. Sandy or gravelly soils generally have rapid permeability, which might allow noxious liquids to contaminate ground water.

Unless otherwise stated, the limitations in table 5 apply only to the soil material within a depth of about 6 feet. If the trench is deeper, a limitation of slight or moderate may not be valid. Site investigation is needed before a site is selected.

In the area type of sanitary landfill, the limitations imposed by soil texture, depth to bedrock, and stone content do not apply. Soil wetness, however, can be a limitation because it makes the operation of equipment difficult.

Daily cover for landfill should be soil that is easy to excavate and spread over the compacted fill during wet and dry weather. Soils that are loamy or silty and free of stones or boulders are better than other soils. Clayey soils may be sticky and difficult to spread; sandy soils may be subject to soil blowing.

The soils selected for final cover of landfills should be suitable for growing plants. Of all the horizons, the A horizon in most soils has the best workability, more organic matter, and the best potential for growing plants. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

Where it is necessary to bring in soil material for daily or final cover, thickness of suitable soil material available and depth to a seasonal high water table in soils surrounding the sites should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas, such as slope, erodibility, and potential for plant growth.

Construction materials

The suitability of each soil as a source of roadfill, sand, gravel, and topsoil is indicated in table 6 by ratings of good, fair, or poor. The texture, thickness, and organic-matter content of each soil horizon are important factors in rating soils for use as construction material. Each soil is evaluated to the depth observed, generally about 6 feet.

Roadfill is soil material used in embankments for roads. The ratings reflect the ease of excavating and working the material and the expected performance of the material after it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but information about soil properties that influence such performance is given in the descriptions of the soil series.

The ratings apply to the soil profile between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within their profile. The estimated engineering properties in table 10 provide specific information about the nature of each horizon. This information can help determine the suitability of each horizon for roadfill.

Soils rated *good* have low shrink-swell potential, low frost action potential, and few cobbles and stones. They are at least moderately well drained and have slopes of 15 percent or less. Soils rated *fair* have a plasticity index of less than 15 and have other limiting features, such as high shrink-swell potential, high frost action potential, steep slopes, wetness, or many stones. If the thickness of suitable material is less than 3 feet, the entire soil is rated *poor*.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 6 provide guidance as to where to look for probable sources and are based on the probability that soils in a given area contain sizable quantities of sand or gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is within a depth of 6 feet. Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered to be sand and gravel. Fine-grained soils are not suitable sources of sand and gravel.

The ratings do not consider depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, and stratification are given in the soil series descriptions and in table 10.

Topsoil is used in areas where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material in preparing a seedbed and by the ability of the soil material to support plant life. Also considered is the damage that can result in the area from which the topsoil is taken.

Soils rated *good* have at least 16 inches of friable loamy material at their surface. They are free of stones, are low in content of gravel and other coarse fragments, and are gently sloping. They are low in soluble

TABLE 6.—*Construction materials*

["Shrink-swell" and other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor"]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Judson:				
8B	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
Marshall:				
9B, 9B2, 9C, 9C2, T9, T9B	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: thin layer.
Colo:				
[1] 11B:				
Colo part	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Judson part	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
Shelby:				
24D, 24D2	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
24E, 24E2, 24F2	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Sparta:				
41D	Good	Good	Unsuited	Poor: too sandy.
Bremer:				
43	Poor: shrink-swell, frost action, low strength.	Unsuited	Unsuited	Poor: wetness.
Zook:				
54, 54+	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness, too clayey.
Ladoga:				
76B, 76C, 76C2	Poor: frost action	Unsuited	Unsuited	Fair: thin layer.
76D, 76D2	Poor: frost action	Unsuited	Unsuited	Fair: thin layer, slope.
Nevin:				
88	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
Shelby:				
[1] 93D:				
Shelby part	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
Adair part	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
[1] 93D2:				
Shelby part	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
Adair part	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
[1] 93E2:				
Shelby part	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Adair part	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
Marshall:				
99C, 99C2	Poor: low strength, frost action.	Unsuited	Unsuited	Fair.
99D, 99D2	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: thin layer, slope.

TABLE 6.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Colo:				
133, 133+	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Wabash:				
172	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: wetness, too clayey.
Gara:				
179D, 179D2	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
179E2, 179F2	Poor: low strength	Unsuited	Unsuited	Poor: slope.
179G2	Poor: low strength, slope.	Unsuited	Unsuited	Poor: slope.
Adair:				
192C, 192C2, 192D, 192D2	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
Kennebec:				
212	Poor: excess humus, frost action, low strength.	Unsuited	Unsuited	Good.
Nodaway:				
220	Poor: frost action	Unsuited	Unsuited	Good.
Wabash:				
248, 248+	Poor: wetness, shrink-swell, low strength.	Unsuited: excess fines.	Unsuited: excess fines.	Poor: wetness, too clayey.
Olmitz:				
273B, 273C	Poor: low strength	Unsuited	Unsuited	Good.
Minden:				
T299	Poor: low strength, frost action.	Unsuited	Unsuited	Good.
Macksburg:				
T368	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Good.
Winterset:				
T369	Poor: shrink-swell, wetness, low strength.	Unsuited	Unsuited	Poor: wetness.
Sharpsburg:				
370, 370B, 370B2, 370C, 370C2, T370B, T370C	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
370D, 370D2	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: slope, thin layer.
Mayberry:				
692C2, 692D, 692D2	Poor: shrink-swell, frost action, low strength.	Unsuited	Unsuited	Poor: thin layer, area reclaim.
Alluvial land, sandy:				
715	Poor: wetness, frost action.	Fair: excess fines	Fair: excess fines	Poor: wetness, area reclaim.
Northboro:				
751C, 751C2, 751D, 751D2	Poor: frost action	Poor: excess fines	Poor: excess fines	Poor: area reclaim.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

salts that can restrict plant growth. They are naturally fertile or respond well to fertilizer. They are not so wet that excavation is difficult during most of the year.

Soils rated *fair* are loose sandy or firm loamy or clayey soils in which the suitable material is only 8 to 16 inches thick or soils that have appreciable amounts of gravel, stones, or soluble salt.

Soils rated *poor* are very sandy soils or very firm clayey soils; soils that have suitable layers less than 8 inches thick; soils that have large amounts of gravel, stones, or soluble salt; steep soils; and poorly drained soils.

Although a rating of *good* is not based entirely on high content of organic matter, a surface horizon is generally preferred for topsoil because of its organic matter content. This horizon is designated as A1 or Ap in the soil series descriptions. Organic matter in the A1 or Ap horizon greatly increases the absorption and retention of moisture and nutrients. Therefore, the soil material from these horizons should be carefully preserved for later use.

Water management

Many soil properties and site features that affect water management have been identified in this soil survey. In table 7, the degree of soil limitation and soil and site features that affect use are indicated for each kind of soil. This information is significant in planning, installing, and maintaining water control structures.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for this use have a low seepage potential, which is determined by permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage, erosion, and piping and has favorable stability, shrink-swell potential, shear strength, and compaction characteristics. Stones and organic matter in a soil downgrade the suitability of the soil for use in embankments, dikes, and levees.

Drainage of soil is affected by such properties as permeability, texture, structure, depth to claypan or other layers that influence rate of water movement, depth to the water table, slope, stability of ditchbanks, susceptibility to flooding, salinity and alkalinity, and availability of outlets for drainage.

Irrigation is affected by such features as slope, susceptibility to flooding, hazards of erosion and soil blowing, texture, salinity and alkalinity, depth of root zone, rate of water absorption at the surface, permeability below the surface layer, available water capacity, need for drainage, and depth to the water table.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to intercept runoff. They allow water to soak into the soil or flow slowly to an outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope, depth to bedrock or other unfavorable material, permeability, ease of establishing vegetation, and resistance to erosion, soil blowing, soil slipping, and piping.

Grassed waterways are constructed to channel runoff to outlets at a nonerosive velocity. Features that affect the use of soils for waterways are slope, permeability, erodibility, and suitability for permanent vegetation.

Recreation

The soils of the survey area are rated in table 8 according to limitations that affect their suitability for recreation uses. The ratings are based on such restrictive soil features as flooding, wetness, slope, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are location and accessibility of the area, size and shape of the area and its scenic quality, the ability of the soil to support vegetation, access to water, potential water impoundment sites available, and either access to public sewerlines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited, in varying degree, for recreation use by the duration and intensity of flooding and the season when flooding occurs. Onsite assessment of height, duration, intensity, and frequency of flooding is essential in planning recreation facilities.

The degree of the limitation of the soils is expressed as slight, moderate, or severe. *Slight* means that the soil properties are generally favorable and that the limitations are minor and easily overcome. *Moderate* means that the limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 8 can be supplemented by information in other parts of this survey. Especially helpful are interpretations for septic tank absorption fields, given in table 5, and interpretations for dwellings without basements and for local roads and streets, given in table 4.

Camp areas require such site preparation as shaping and leveling for tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils for this use have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing camping sites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for use as picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that will increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones or boulders, is firm after rains, and is not dusty when dry. If shaping is required to obtain a uniform grade, the depth of the soil over bedrock or hardpan should be enough to allow necessary grading.

TABLE 7.—*Water management*

["Seepage" and other terms that describe restrictive soil features are defined in the Glossary]

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Judson:						
8B	Seepage	Compressible, low strength, shrink-swell.	Not needed	Favorable	Favorable	Favorable.
Marshall:						
9B, 9B2, 9C, 9C2, T9, T9B	Seepage	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Colo:						
[1] 11B:						
Colo part	Favorable	Compressible, low strength, hard to pack.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
Judson part	Seepage	Compressible, low strength, shrink-swell.	Not needed	Favorable	Favorable	Favorable.
Shelby:						
24D, 24D2, 24E, 24E2, 24F2	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
Sparta:						
41D	Seepage	Piping	Not needed	Seepage, droughty.	Too sandy	Droughty.
Bremer:						
43	Favorable	Compressible, unstable fill, shrink-swell.	Percs slowly	Slow intake, wetness.	Not needed	Not needed.
Zook:						
54, 54+	Favorable	Shrink-swell, low strength, hard to pack.	Floods, wetness, percs slowly.	Floods, wetness, percs slowly.	Not needed	Wetness.
Ladoga:						
76B, 76C, 76C2, 76D, 76D2	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Nevin:						
88	Favorable	Compressible, low strength, shrink-swell.	Favorable	Favorable	Not needed	Not needed.
Shelby:						
[1] 93D:						
Shelby part	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
Adair part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, percs slowly, slow intake.	Complex slope	Percs slowly.
[1] 93D2:						
Shelby part	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
Adair part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, percs slowly, slow intake.	Complex slope	Percs slowly.

TABLE 7.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
[1] 93E2: Shelby part	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
Adair part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, percs slowly, slow intake.	Complex slope	Percs slowly.
Marshall: 99C, 99C2, 99D, 99D2	Seepage	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Colo: 133, 133+	Favorable	Compressible, low strength, hard to pack.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
Wabash: 172	Favorable	Shrink-swell, compressible, low strength.	Floods, percs slowly, wetness.	Slow intake, wetness, floods.	Percs slowly, wetness.	Percs slowly, wetness.
Gara: 179D, 179D2, 179E2, 179F2, 179G2	Slope	Low strength, shrink-swell.	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.
Adair: 192C, 192C2, 192D, 192D2	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, percs slowly, slow intake.	Complex slope	Percs slowly.
Kennebec: 212	Seepage	Low strength, compressible, excess humus.	Floods, frost action.	Floods	Favorable	Favorable.
Nodaway: 220	Seepage	Low strength	Floods	Floods	Not needed	Not needed.
Wabash: 248, 248+	Favorable	Shrink-swell, compressible, low strength.	Floods, percs slowly, wetness.	Slow intake, wetness, floods.	Percs slowly, wetness.	Percs slowly, wetness.
Olmitz: 273B, 273C	Favorable	Favorable	Not needed	Favorable	Erodes easily	Erodes easily.
Minden: T299	Favorable	Compressible, low strength, shrink-swell.	Not needed	Favorable	Not needed	Not needed.
Macksburg: T368	Favorable	Compressible, low strength, shrink-swell.	Favorable	Wetness	Favorable	Favorable.
Winterset: T369	Favorable	Compressible, low strength, shrink-swell.	Percs slowly	Wetness, percs slowly, slow intake.	Not needed	Not needed.
Sharpsburg: 370, 370B, 370B2, 370C, 370C2, 370D, 370D2, T370B, T370C	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.

TABLE 7.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Mayberry: 692C2, 692D, 692D2	Slope	Shrink-swell, low strength.	Percs slowly	Slow intake, percs slowly, slope.	Percs slowly, erodes easily.	Percs slowly, erodes easily.
Alluvial land, sandy: 715	Seepage	Low strength, compressible.	Floods	Floods	Not needed	Not needed.
Northboro: 751C, 751C2, 751D, 751D2	Seepage, slope	Erodes easily	Percs slowly, slope.	Slope, erodes easily.	Slope, complex slope.	Erodes easily, percs slowly.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

Paths and trails for walking, horseback riding, bicycling, and other uses should require little or no cutting and filling. The best soils for this use are those that are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once during the annual period of use. They should have moderate slopes and have few or no stones or boulders on the surface.

Wildlife habitat

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the construction of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, is inadequate, or is inaccessible, wildlife either are scarce or do not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, and by helping the natural establishment of desirable plants.

In table 9 the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in—

1. Planning for parks, wildlife refuges, nature study areas, and other developments for wildlife.
2. Selecting areas that are suitable for wildlife.
3. Selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat.
4. Determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of habitat are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed-producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, barley, millet, buckwheat, cowpeas, soybeans, and sunflowers. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bluegrass, lovegrass, switchgrass, bromegrass, timothy, orchardgrass, clover, alfalfa, trefoil, and crownvetch. Major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations.

Wild herbaceous plants are native or naturally established herbaceous grasses and forbs, including weeds, that provide food and cover for wildlife. Examples are bluestem, indiangrass, goldenrod, beggarweed, pokeweed, partridgepea, wheatgrass, fescue, and grama. Major soil properties that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Hardwood trees and the associated woody under-

TABLE 8.—*Recreational development*

["Percs slowly" and other terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe"]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Judson:				
8B	Moderate: too clayey	Moderate: too clayey	Moderate: slope, too clayey.	Moderate: too clayey.
Marshall:				
9B, 9B2, T9B	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
9C, 9C2	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.
T9	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
Colo:				
[1] 11B:				
Colo part	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Judson part	Moderate: too clayey	Moderate: too clayey	Moderate: slope, too clayey.	Moderate: too clayey.
Shelby:				
24D, 24D2	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
24E, 24E2, 24F2	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Sparta:				
41D	Moderate: too sandy, slope.	Moderate: too sandy, slope.	Severe: slope	Moderate: too sandy.
Bremer:				
43	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Zook:				
54, 54+	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Ladoga:				
76B	Moderate: percs slowly.	Slight	Moderate: percs slowly, slope.	Slight.
76C, 76C2	Moderate: percs slowly.	Slight	Severe: slope	Slight.
76D, 76D2	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
Nevin:				
88	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
Shelby:				
[1] 93D:				
Shelby part	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
Adair part	Moderate: percs slowly, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
[1] 93D2:				
Shelby part	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
Adair part	Moderate: percs slowly, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
[1] 93E2:				
Shelby part	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Adair part	Severe: slope	Severe: slope	Severe: slope	Moderate: wetness.

TABLE 8.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Marshall:				
99C, 99C2	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.
99D, 99D2	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
Colo:				
133, 133+	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Wabash:				
172	Severe: floods, wetness, percs slowly.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, percs slowly.	Severe: wetness, too clayey.
Gara:				
179D, 179D2	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
179E2, 179F2	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
179G2	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Adair:				
192C, 192C2	Moderate: percs slowly.	Moderate: wetness	Severe: slope	Moderate: wetness.
192D, 192D2	Moderate: percs slowly, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
Kennebec:				
212	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Nodaway:				
220	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Wabash:				
248, 248+	Severe: floods, wetness, percs slowly.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, percs slowly.	Severe: wetness, too clayey.
Olmitz:				
273B	Slight	Slight	Moderate: slope	Slight.
273C	Slight	Slight	Severe: slope	Slight.
Minden:				
T299	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
Macksburg:				
T368	Moderate: wetness, too clayey, percs slowly.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
Winterset:				
T369	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Sharpsburg:				
370, 370B, 370B2, T370B	Moderate: percs slowly, too clayey.	Moderate: too clayey	Moderate: too clayey, percs slowly.	Moderate: too clayey.
370C, 370C2, T370C	Moderate: percs slowly, too clayey.	Moderate: too clayey	Severe: slope	Moderate: too clayey.
370D, 370D2	Moderate: percs slowly, too clayey.	Moderate: slope, too clayey.	Severe: slope	Moderate: too clayey.
Mayberry:				
692C2	Moderate: percs slowly , too clayey.	Moderate: too clayey	Severe: slope	Moderate: too clayey.
692D, 692D2	Moderate: percs slowly, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.

TABLE 8.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Alluvial land, sandy:				
715	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
Northboro:				
751C, 751C2	Moderate: percs slowly.	Slight	Severe: slope	Slight.
751D, 751D2	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

story provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Examples of hardwood plants are oak, poplar, cherry, sweetgum, apple, hawthorn, dogwood, persimmon, sassafras, sumac, hickory, hazelnut, black walnut, blackberry, grape, blackhaw, viburnum, blueberry, bayberry, and briers. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated good are Russian-olive, autumn-olive, and crabapple. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness.

Coniferous plants are cone-bearing trees, shrubs, or ground cover plants that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. Examples are pine, spruce, hemlock, fir, yew, cedar, and juniper. Major soil properties that affect the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Examples of wetland plants are smartweed, wild millet, rushes, sedges, reeds, wildrice, saltgrass, cordgrass, and cattail. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas are bodies of water that have an average depth of less than 5 feet and are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control structures in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, and ponds. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland habitat consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck.

Woodland habitat consists of areas of hardwoods or conifers, or a mixture of both, with associated grasses, legumes, and wild herbaceous plants. Examples of wildlife attracted to this habitat are wild turkey, ruffed grouse, woodcock, thrushes, vireos, woodpeckers, tree squirrels, gray fox, raccoon, deer, elk, and black bear.

Wetland habitat consists of open, marshy or swampy, shallow water areas where water-tolerant plants grow. Examples of wildlife attracted to this habitat are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, mink, and beaver.

Soil properties

Extensive data about soil properties are summarized on the following pages. The two main sources of these data are the many thousands of soil borings made during the course of the survey and the laboratory analyses of selected soil samples from representative soil profiles.

In making soil borings during field mapping, soil scientists can identify several important soil properties. They note the seasonal soil moisture condition or the presence of free water and its depth. For each horizon in the profile, they note the thickness and color of the soil material; the texture, or amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or natural pattern of cracks and pores in the undisturbed soil; and the consistence of soil material in-place under the existing soil moisture conditions. They record the depth of plant roots, determine the pH or reaction of the soils, and identify any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to characterize key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil series in the survey area, but laboratory data for many of the soil series not tested are available from nearby areas.

The available field and laboratory data are summarized in tables. The tables give the estimated range of engineering properties, the engineering classifications, and the physical and chemical properties of each major horizon of each soil in the survey area. They also present data about pertinent soil and water features, engineering test data, and data obtained from physical and chemical laboratory analyses of soils.

Engineering properties

Table 10 gives estimates of engineering properties and classifications for the major horizons of each soil in the survey area. These estimates are presented as ranges in values most likely to exist in areas where the soil is mapped.

Most soils have horizons of contrasting properties within the upper 5 or 6 feet. Table 10 gives information for each of these contrasting horizons in a typical profile. Depth to the upper and lower boundaries of each horizon is indicated. More information about the range in depth and about other properties of each horizon is given for each soil series in "Soil series descriptions and morphology."

Texture is described in table 10 in standard terms used by the United States Department of Agriculture. These terms are defined according to 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 a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms used by USDA are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified Soil Classification System (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*). In table 10 soils in the survey area are classified according to both systems.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter, plasticity index, liquid limit, and organic matter content. Soils are grouped into 15 classes—eight classes of coarse grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes have a dual classification symbol, for example CL–ML.

The AASHTO system classifies soils according to those properties that affect their use in highway construction and maintenance. In this system a mineral soil is classified in one of seven basic groups ranging from A–1 through A–7 on the basis of grain size distribution, liquid limit, and plasticity index. Soils in group A–1 are coarse grained and low in content of fines. At the other extreme, in group A–7, are fine grained soils. Highly organic soils are classified in group A–8 on the basis of visual inspection.

When laboratory data are available, the A–1, A–2, and A–7 groups are further classified as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or higher for the poorest. The estimated classification, without group index numbers, is given in table 10. Also in table 10 the percentage, by weight, of cobbles or the rock fragments more than 3 inches in diameter are estimated for each major horizon. These estimates are determined largely by observing volume percentage in the field and then converting that, by formula, to weight percentage.

Percentage of the soil material less than 3 inches in diameter that passes each of four sieves (U.S. standard) is estimated for each major horizon. The estimates are based on tests of soils that were sampled in the survey area and in nearby areas and on field estimates from many borings made during the survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil. These indexes are used in both the Unified and the AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior. Range in liquid limit and in plasticity index is estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey.

Physical and chemical properties

Table 11 shows estimated values for several soil characteristics and features that affect behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the representative profile of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships among the soil characteristics observed in the field—particularly soil structure, porosity, and gradation or texture—that influence the downward movement of water in the soil. The estimates are for vertical water movement when the soil is saturated. Not considered in the estimates are lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to be considered in planning and designing drainage systems, in evaluating the potential of soils for septic tank systems and other waste disposal systems, and in many other aspects of land use and management.

Available water capacity is rated on the basis of soil characteristics that influence the ability of the soil to hold water and make it available to plants. Important characteristics are content of organic matter, soil texture, and soil structure. Shallow-rooted plants are not likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design of irrigation systems.

Soil reaction is expressed as a range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops, ornamental plants, or other plants to be grown; in evaluating soil amendments for fertility and stabilization; and in evaluating the corrosivity of soils.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others the swelling was estimated on the basis of the kind and amount of clay in the soil

TABLE 9.—*Wildlife*

[See text for definitions of "good,"

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
Judson:				
8B	Good	Good	Good	Good
Marshall:				
9B, 9B2, 9C, 9C2, T9, T9B	Good	Good	Good	Fair
Colo:				
[1] 11B:				
Colo part	Good	Fair	Good	Fair
Judson part	Good	Good	Good	Good
Shelby:				
24D, 24D2	Fair	Good	Fair	Good
24E, 24E2, 24F2	Poor	Fair	Fair	Fair
Sparta:				
41D	Poor	Fair	Fair	Fair
Bremer:				
43	Good	Good	Good	Fair
Zook:				
54, 54+	Good	Fair	Good	Fair
Ladoga:				
76B	Good	Good	Fair	Good
76C, 76C2, 76D, 76D2	Fair	Good	Fair	Good
Nevin:				
88	Good	Good	Good	Good
Shelby:				
[1] 93D:				
Shelby part	Fair	Good	Fair	Good
Adair part	Fair	Good	Fair	Fair
[1] 93D2:				
Shelby part	Fair	Good	Fair	Good
Adair part	Fair	Good	Fair	Fair
[1] 93E2:				
Shelby part	Poor	Fair	Fair	Fair
Adair part	Fair	Good	Fair	Fair
Marshall:				
99C, 99C2, 99D, 99D2	Good	Good	Good	Fair
Colo:				
133, 133+	Good	Fair	Good	Fair
Wabash:				
172	Poor	Poor	Poor	Poor
Gara:				
179D, 179D2	Fair	Good	Fair	Good
179E2, 179F2	Poor	Fair	Fair	Fair
179G2	Very poor	Very poor	Fair	Fair
Adair:				
192C, 192C2, 192D, 192D2	Fair	Good	Fair	Fair
Kennebec:				
212	Good	Good	Good	Good
Nodaway:				
220	Good	Good	Good	Good
Wabash:				
248, 248+	Poor	Poor	Poor	Poor

habitat potentials

"fair," "poor," and "very poor"]

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Good	Poor	Poor	Good	Good	Poor
Fair	Poor	Poor	Good	Fair	Poor
Poor	Fair	Very poor	Fair	Fair	Poor
Good	Poor	Poor	Good	Good	Poor
Good	Poor	Poor	Fair	Good	Poor
Fair	Poor	Poor	Fair	Fair	Poor
Fair	Very poor	Very poor	Fair	Fair	Very poor
Poor	Good	Good	Good	Fair	Good
Poor	Good	Good	Fair	Fair	Good
Good	Poor	Poor	Good	Good	Poor
Good	Very poor	Poor	Fair	Good	Very poor
Good	Fair	Fair	Good	Good	Fair
Good	Poor	Poor	Fair	Good	Poor
Fair	Poor	Poor	Good	Fair	Poor
Good	Poor	Poor	Fair	Good	Poor
Fair	Poor	Poor	Good	Fair	Poor
Fair	Poor	Poor	Fair	Fair	Poor
Fair	Poor	Poor	Good	Fair	Poor
Fair	Poor	Poor	Good	Fair	Poor
Poor	Good	Good	Fair	Fair	Good
Poor	Poor	Good	Poor	Poor	Fair
Good	Very poor	Poor	Fair	Good	Poor
Fair	Very poor	Very poor	Fair	Fair	Very poor
Fair	Very poor	Very poor	Poor	Fair	Very poor
Fair	Poor	Poor	Good	Fair	Poor
Good	Poor	Poor	Good	Good	Poor
Fair	Fair	Poor	Fair	Good	Fair
Poor	Good	Good	Poor	Poor	Good

TABLE 9.—*Wildlife*

Soil name and map symbol	Potential for habitat elements			
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees
Olmitz:				
273B	Good	Good	Fair	Good
273C	Fair	Good	Fair	Good
Minden:				
T299	Good	Good	Good	Good
Macksburg:				
T368	Good	Good	Good	Good
Winterset:				
T369	Good	Fair	Fair	Fair
Sharpsburg:				
370, 370B, 370B2, T370B	Good	Good	Good	Good
370C, 370C2, 370D, 370D2, T370C	Fair	Good	Good	Good
Mayberry:				
692C2, 692D, 692D2	Fair	Good	Fair	
Alluvial land, sandy:				
715	Poor	Fair	Fair	Fair
Northboro:				
751C, 751C2, 751D, 751D2	Fair	Good	Fair	Good

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and

and on measurements of similar soils. The size of the load and the magnitude of the change in soil moisture content also influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A high shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rate of corrosion of concrete is based mainly on the sulfate content, texture, and acidity of the soil. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Uncoated steel intersecting soil boundaries or soil horizons is more susceptible to corrosion than an installation that is entirely within one kind of soil or within one soil horizon.

Erosion factors are used to predict the erodibility of a soil and its tolerance to erosion in relation to specific kinds of land use and treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values range from 0.10 to 0.64. To estimate annual soil loss per acre, the K value of a soil is modified by factors representing plant cover, grade and length of slope, management practices, and climate. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or soil blowing, that can occur without reducing crop production or environmental quality. The rate is expressed in tons of soil loss per acre per year.

Wind erodibility groups are made up of soils that have similar properties that affect their resistance to soil blowing if cultivated. The groups are used to predict the susceptibility of soil to blowing and the amount of soil lost as a result of blowing. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are extremely erodible, so vegetation is difficult to establish. They are generally not suitable for crops.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible, but crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible, but crops can be grown if measures to control soil blowing are used.

habitat potentials—Continued

Potential for habitat elements—Continued			Potential as habitat for—		
Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Good Good	Poor Very poor	Poor Very poor	Good Fair	Good Good	Poor Very poor
Good	Fair	Fair	Good	Good	Fair
Good	Fair	Fair	Good	Good	Fair
Poor	Good	Good	Fair	Fair	Good
Good Good	Poor Poor	Poor Poor	Good Good	Good Good	Poor Poor
Fair	Very poor	Very poor	Fair		Very poor
Poor	Good	Fair	Fair	Fair	Fair
Good	Very poor	Very poor	Good	Good	Very poor

behavior characteristics of the mapping unit.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible, but crops can be grown if measures to control soil blowing are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible, and crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible, and crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to soil blowing.

Soil and water features

Table 12 contains information helpful in planning land uses and engineering projects that are likely to be affected by soil and water features.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups on the basis of the intake of water after the soils have been wetted and have received precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water or soils that have moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is the temporary covering of soil with water from overflowing streams, with runoff from adjacent slopes, and by tides. Water standing for short periods after rains or after snow melts is not considered flooding, nor is water in swamps and marshes. Flooding is rated in general terms that describe the frequency and duration of flooding and the time of year when flooding is most likely. The ratings are based on evidence in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic-matter content with increasing

TABLE 10.—*Engineering properties*

[The symbol > means more than. Dashes

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Judson:				
8B	0–33	Silty clay loam	OL, CL, CL–ML, ML	A–6, A–7, A–4
	33–60	Silty clay loam, silt loam	CL, CL–ML, ML	A–6, A–7, A–4
Marshall:				
9B, 9B2, 9C, 9C2, T9, T9B	0–15	Silty clay loam	ML, CL	A–6, A–7
	15–60	Silty clay loam	CL, CH	A–7
Colo:				
[1] 11B:				
Colo part	0–29	Silty clay loam	CL, CH	A–7
	29–60	Silty clay loam	CL, CH	A–7
Judson part	0–33	Silty clay loam	OL, CL, CL–ML, ML	A–6, A–7, A–4
	33–60	Silty clay loam, silt loam	CL, CL–ML, ML	A–6, A–7, A–4
Shelby:				
24D, 24D2, 24E, 24E2, 24F2	0–10	Clay loam	CL	A–6
	10–38	Clay loam	CL	A–6, A–7
	38–60	Clay loam	CL	A–6, A–7
Sparta:				
41D	0–15	Loamy fine sand	SM, SP–SM	A–2
	15–60	Sand	SP	A–3
Bremer:				
43	0–24	Silty clay loam	MH, CH	A–7
	24–48	Silty clay loam, silty clay	CH	A–7
	48–60	Silty clay loam	CH, CL	A–7
Zook:				
54	0–21	Silty clay loam	MH, CH, CL, OL	A–7
	21–60	Silty clay, silty clay loam	CH	A–7
54+	0–21	Silt loam	CL, CL–ML	A–4, A–6
	21–60	Silty clay, silty clay loam	CH	A–7
Ladoga:				
76B, 76C, 76C2, 76D, 76D2	0–11	Silt loam	CL, CL–ML	A–6, A–4
	11–60	Silty clay loam	CL, CH	A–7
Nevin:				
88	0–24	Silty clay loam	CL, OL	A–6, A–7
	24–48	Silty clay loam	CL	A–7
	48–60	Silty clay loam	CL	A–7
Shelby:				
[1] 93D:				
Shelby part	0–10	Clay loam	CL	A–6
	10–38	Clay loam	CL	A–6, A–7
	38–60	Clay loam	CL	A–6, A–7
Adair part	0–26	Clay loam	CL	A–6
	26–42	Silty clay, silty clay loam	CL, CH	A–7
	42–60	Clay loam	CL	A–6, A–7
[1] 93D2:				
Shelby part	0–10	Clay loam	CL	A–6
	10–38	Clay loam	CL	A–6, A–7
	38–60	Clay loam	CL	A–6, A–7
Adair part	0–26	Clay loam	CL	A–6
	26–42	Silty clay, clay, clay loam	CL, CH	A–7
	42–60	Clay loam	CL	A–6, A–7

and classifications

indicate that data were not estimated]

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	100	95–100	25–50	5–25
0	100	100	100	95–100	25–50	5–25
0	100	100	100	95–100	35–50	15–25
0	100	100	100	95–100	45–60	25–35
0	100	100	90–100	90–100	41–60	15–30
0	100	100	90–100	90–100	41–55	15–30
0	100	100	100	95–100	25–50	5–25
0	100	100	100	95–100	25–50	5–25
0	90–100	85–98	75–90	55–70	30–40	11–20
0	90–100	85–98	75–90	55–70	35–45	15–25
0	90–100	85–98	75–90	55–70	35–45	15–25
0	100	100	60–70	10–20	---	NP
0	100	100	65–75	1–5	---	NP
0	100	100	100	95–100	45–60	25–40
0	100	100	100	95–100	50–65	20–35
0	100	100	95–100	95–100	40–60	25–40
0	100	100	95–100	95–100	45–70	20–40
0	100	100	95–100	95–100	60–85	40–60
0	100	100	95–100	95–100	25–40	5–15
0	100	100	95–100	95–100	60–85	40–60
0	100	100	100	95–100	25–40	5–15
0	100	100	100	95–100	41–55	25–35
0	100	100	100	90–95	35–45	10–20
0	100	100	95–100	90–95	40–50	20–30
0	100	100	95–100	90–95	40–50	20–30
0	90–100	85–98	75–90	55–70	30–40	11–20
0	90–100	85–98	75–90	55–70	35–45	15–25
0	90–100	85–98	75–90	55–70	35–45	15–25
0	95–100	80–95	75–90	60–80	30–40	11–20
0	95–100	80–95	70–90	55–80	45–55	20–30
0	95–100	80–95	70–90	55–80	35–45	15–25
0	90–100	85–98	75–90	55–70	30–40	11–20
0	90–100	85–98	75–90	55–70	35–45	15–25
0	90–100	85–98	75–90	55–70	35–45	15–25
0	95–100	80–95	75–90	60–80	30–40	11–20
0	95–100	80–95	70–90	55–80	45–55	20–30
0	95–100	80–95	70–90	55–80	35–45	15–25

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO
	In			
[1] 93E2:				
Shelby part	0–10	Clay loam	CL	A–6
	10–38	Clay loam	CL	A–6, A–7
	38–60	Clay loam	CL	A–6, A–7
Adair part	0–26	Clay loam	CL	A–6
	26–42	Silty clay, clay, clay loam	CL, CH	A–7
	42–60	Clay loam	CL	A–6, A–7
Marshall: 99C, 99C2, 99D, 99D2	0–11	Silty clay loam	ML, CL	A–6, A–7
	11–60	Silty clay loam	CL, CH	A–7
Colo: 133	0–29	Silty clay loam	CL, CH	A–7
	29–60	Silty clay loam	CL, CH	A–7
133+	0–15	Silt loam	CL, CL–ML	A–4, A–6
	15–29	Silty clay loam	CL, CH	A–7
Wabash: 172	0–15	Silty clay	CH	A–7
	15–60	Silty clay, clay	CH	A–7
Gara: 179D, 179D2, 179E2, 179F2, 179G2	0–12	Loam	CL, CL–ML	A–4, A–6
	12–46	Clay loam	CL	A–6
	46–60	Loam, clay loam	CL	A–6
Adair: 192C, 192C2, 192D, 192D2	0–26	Clay loam	CL	A–6
	26–42	Silty clay, clay, clay loam	CL, CH	A–7
	42–60	Clay loam	CL	A–6, A–7
Kennebec: 212	0–45	Silt loam	CL, ML, CL–ML	A–6, A–7, A–4
	45–60	Silt loam, silty clay loam	CL	A–6, A–7, A–4
Nodaway: 220	0–60	Silt loam	CL, CL–ML	A–4, A–6
Wabash: 248	0–15	Silty clay loam	CL, CH	A–6, A–7
	15–60	Silty clay, clay	CH	A–7
248+	0–15	Silt loam	CL, CH	A–6, A–7
	15–60	Silty clay, clay	CH	A–7
Olmitz: 273B, 273C	0–21	Loam	CL	A–6
	21–60	Clay loam	CL	A–6, A–7
Minden: T299	0–22	Silty clay loam	OL, CL	A–7
	22–46	Silty clay loam	CL, CH	A–7
	46–60	Silt loam	CL	A–7
Macksburg: T368	0–22	Silty clay loam	ML, OL, CL	A–7
	22–42	Silty clay loam, silty clay	CH	A–7
	42–60	Silty clay loam	CL	A–7
Winterset: T369	0–24	Silty clay loam	CL, OL	A–7
	24–31	Silty clay, silty clay loam	CH	A–7
	31–60	Silty clay loam	CL, CH	A–7

and classifications—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	90–100	85–98	75–90	55–70	30–40	11–20
0	90–100	85–98	75–90	55–70	35–45	15–25
0	90–100	85–98	75–90	55–70	35–45	15–25
0	95–100	80–95	75–90	60–80	30–40	11–20
0	95–100	80–95	70–90	55–80	45–55	20–30
0	95–100	80–95	70–90	55–80	35–45	15–25
0	100	100	100	95–100	35–50	15–25
0	100	100	100	95–100	45–60	25–35
0	100	100	90–100	90–100	41–60	15–30
0	100	100	90–100	90–100	41–55	15–30
0	100	100	95–100	95–100	25–40	5–15
0	100	100	90–100	90–100	41–55	15–30
0	100	100	100	95–100	52–75	30–55
0	100	100	100	95–100	52–78	30–55
0	85–95	80–90	70–80	55–70	20–30	5–15
0	85–95	80–90	70–85	55–75	30–40	15–25
0	85–95	80–90	70–85	55–75	35–45	15–25
0	95–100	80–95	75–90	60–80	30–40	11–20
0	95–100	80–95	70–90	55–80	45–55	20–30
0	95–100	80–95	70–90	55–80	35–45	15–25
0	100	100	95–100	90–100	30–50	5–25
0	100	100	95–100	90–100	30–50	5–20
0	100	95–100	95–100	90–100	25–35	5–15
0	100	100	100	95–100	30–55	12–35
0	100	100	100	95–100	52–78	30–55
0	100	100	100	95–100	30–55	12–35
0	100	100	100	95–100	52–78	30–55
0	100	90–100	85–95	60–80	30–40	11–20
0	100	90–100	85–95	60–80	35–45	15–25
0	100	100	100	95–100	41–50	15–25
0	100	100	100	95–100	45–60	25–35
0	100	100	100	95–100	40–50	20–30
0	100	100	100	95–100	41–50	15–25
0	100	100	100	95–100	50–60	25–35
0	100	100	100	95–100	41–50	20–30
0	100	100	100	95–100	40–50	20–30
0	100	100	100	95–100	50–70	30–40
0	100	100	100	95–100	45–55	25–35

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Sharpsburg:				
370, 370B, 370B2, 370C, 370C2, 370D, 370D2, T370B, T370C	0–16	Silty clay loam	OL, CL, CH, OH	A–7, A–6
	16–34	Silty clay loam, silty clay	CH, CL	A–7, A–6
	34–60	Silty clay loam	CL	A–7, A–6
Mayberry:				
692C2, 692D, 692D2	0–10	Clay loam	CL	A–6, A–7
	10–46	Clay, silty clay, sandy clay	CH	A–7
	46–60	Clay loam, silty clay loam, clay	CL, CH	A–6, A–7
Alluvial land, sandy:				
715	0–60	Variable	---	---
Northboro:				
751C, 751C2, 751D	0–14	Silt loam	ML, CL	A–6, A–7
	14–40	Silt loam, silty clay loam	ML, CL	A–6, A–7
	40–60	Clay loam, loam	CL	A–7, A–6
751D2	0–14	Silty clay loam	ML, CL	A–6, A–7
	14–40	Silt loam, silty clay loam	ML, CL	A–6, A–7
	40–60	Clay loam, loam	CL	A–7, A–6

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and

depth; and absence of distinctive soil horizons that form in soils of the area that are not subject to flooding. The ratings are also based on local information about floodwater levels in the area and the extent of flooding; and on information that relates the position of each soil on the landscape to historic floods.

The generalized description of flood hazards is of value in land-use planning and provides a valid basis for land-use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table is the highest level of a saturated zone more than 6 inches thick for a continuous period of more than 2 weeks during most years. The depth to a seasonal high water table applies to undrained soils. Estimates are based mainly on the relationship between grayish colors or mottles in the soil and the depth to free water observed in many borings made during the course of the soil survey. Indicated in table 12 are the depth to the seasonal high water table; the kind of water table, that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. Only saturated zones above a depth of 5 or 6 feet are indicated.

Information about the seasonal high water table helps in assessing the need for specially designed foundations, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decide whether or not construction of basements is feasible and to determine how septic tank absorption fields and other underground installations will function. Also, a seasonal high water table affects ease of excavation.

Depth to bedrock is shown for all soils that are underlain by bedrock at a depth of 5 or 6 feet or less. For many soils, the limited depth to bedrock is a part of the definition of the soil series. The depths shown are based on measurements made in many soil borings and on other observations during the mapping of the soils. The kind of bedrock and its hardness as related to ease of excavation is also shown. Rippable bedrock can be excavated with a single-tooth ripping attachment on a 200-horsepower tractor, but hard bedrock generally requires blasting.

Potential frost action refers to the likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action results from the movement of soil moisture into the freezing temperature zone in the soil, which causes ice lenses to form. Soil texture, temperature, moisture content, porosity, permeability, and content of organic matter are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained very gravelly or sandy soils are the least susceptible.

Formation and classification of soils

This section consists of two main parts. The first tells how the factors of soil formation have affected *and classifications*—Continued

Fragments >3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	100	95–100	35–55	20–30
0	100	100	100	95–100	35–60	20–35
0	100	100	100	95–100	35–50	20–30
0	100	95–100	90–100	75–100	35–45	15–20
0	100	90–100	80–100	60–100	45–60	25–35
0	95–100	95–100	85–95	70–95	35–60	15–25
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0	100	100	95–100	95–100	35–45	10–15
0	100	100	95–100	90–100	35–50	10–15
0	95–100	95–100	85–100	70–90	35–50	15–20
0	100	100	95–100	95–100	35–45	10–15
0	100	100	95–100	90–100	35–50	10–15
0	95–100	95–100	85–100	70–90	35–50	15–20

behavior characteristics of the mapping unit.

the development of soils in Page County. The second explains the system of soil classification currently used and places each soil series in the classes of that system.

Factors of soil formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into 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 profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

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

Parent material

The principal parent materials in Page County are loess, glacial till, alluvium, and windblown sand. Small areas of limestone and shale are exposed in a few places, but no soils have developed from them, and these areas have very little effect on the surrounding soils.

Loess, which was deposited by wind, is the most extensive parent material in the county. It consists mainly of silt-sized particles but includes clay particles and small amounts of sand. Presumably, it was calcareous when deposited. Unweathered loess is silt loam or light silty clay loam.

Ladoga, Winterset, Marshall, and Sharpsburg soils are the major loess-derived soils, and they are on most of the uplands and benches. These soils formed in Wisconsin loess, which is believed to have blown mainly from the flood plain of the Missouri River during the Wisconsin glacial period from about 25,000 to 14,000 (*13, 15*) years ago. The thickness of the loess and the differences among the soils that formed in it are related to the distance from the source (*5, 13*) of the loess. The loess is thinner and finer textured in the eastern part of the county than in the western part. Marshall soils which are in the western part of the county where the loess is about 25 feet thick, contain less clay than Sharpsburg and Winterset soils which are in the eastern part of the county where the loess is about 18 feet thick.

Glacial till is another parent material in Page County. Most of it is from the Kansan Glaciation. The unweathered till is firm, calcareous clay loam. It is a

TABLE 11.—*Physical and chemical*

[The symbol < means less than. The erosion tolerance factor (T) is

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
Judson:				
8B	0–33	0.6–2.0	0.21–0.23	6.1–7.3
	33–60	0.6–2.0	0.21–0.23	6.1–7.8
Marshall:				
9B, 9B2, 9C, 9C2, T9, T9B	0–15	0.6–2.0	0.21–0.23	5.6–6.5
	15–60	0.6–2.0	0.18–0.20	5.6–7.3
Colo:				
[1] 11B:				
Colo part	0–29	0.2–0.6	0.21–0.23	5.6–6.5
	29–60	0.2–0.6	0.18–0.20	6.1–7.3
Judson part	0–33	0.6–2.0	0.21–0.23	6.1–7.3
	33–60	0.6–2.0	0.21–0.23	6.1–7.8
Shelby:				
24D, 24D2, 24E, 24E2, 24F2	0–10	0.6–2.0	0.20–0.22	5.6–6.0
	10–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–60	0.2–0.6	0.16–0.18	6.6–7.8
Sparta:				
41D	0–15	6.0–20	0.12–0.14	5.6–6.0
	15–60	6.0–20	0.06–0.08	5.6–6.0
Bremer:				
43	0–24	0.2–0.6	0.21–0.23	5.6–6.5
	24–48	0.06–0.2	0.15–0.17	6.1–6.5
	48–60	0.2–0.6	0.18–0.20	6.1–6.5
Zook:				
54	0–21	0.2–0.6	0.21–0.23	5.6–7.8
	21–60	0.06–0.2	0.11–0.13	5.6–7.8
54+	0–21	0.6–2.0	0.22–0.24	5.6–7.8
	21–60	0.06–0.2	0.11–0.13	5.6–7.8
Ladoga:				
76B, 76C, 76C2, 76D, 76D2	0–11	0.6–2.0	0.22–0.24	6.1–6.5
	11–60	0.2–0.6	0.18–0.20	5.1–6.0
Nevin:				
88	0–24	0.6–2.0	0.21–0.23	6.1–6.5
	24–48	0.2–2.0	0.18–0.20	6.1–6.5
	48–60	0.2–2.0	0.18–0.20	6.6–7.3
Shelby:				
[1] 93D:				
Shelby part	0–10	0.6–2.0	0.20–0.22	5.6–6.0
	10–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–60	0.2–0.6	0.16–0.18	6.6–7.8
Adair part	0–26	0.2–0.6	0.17–0.19	5.6–6.5
	26–42	0.06–0.2	0.13–0.16	5.1–6.5
	42–60	0.2–0.6	0.14–0.16	5.6–6.5
[1] 93D2:				
Shelby part	0–10	0.6–2.0	0.20–0.22	5.6–6.0
	10–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–60	0.2–0.6	0.16–0.18	6.6–7.8
Adair part	0–26	0.2–0.6	0.17–0.19	5.6–6.5
	26–42	0.06–0.2	0.13–0.16	5.1–6.5
	42–60	0.2–0.6	0.14–0.16	5.6–6.5

properties of soils

for the entire profile. Dashes indicate that data were not estimated]

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Moderate Moderate	Moderate Moderate	Low Low	0.28 0.43	5	7
Moderate Moderate	Moderate Moderate	Moderate Low	0.32 0.43	5	7
High High	High High	Moderate Moderate	--- ---	---	7
Moderate Moderate	Moderate Moderate	Low Low	0.28 0.43	5	7
Moderate Moderate Moderate	Moderate Moderate Moderate	Moderate Moderate Moderate	0.28 0.28 0.37	5	6
Low Low	Low Low	Low Low	0.17 0.17	5	2
Moderate High High	Moderate Moderate Moderate	Moderate Moderate Moderate	--- --- ---	---	7
High High	High High	Moderate Moderate	--- ---	---	7
Moderate High	High High	Moderate Moderate	--- ---	---	6
Low Moderate	Moderate Moderate	Low Moderate	0.32 0.43	5	6
Moderate Moderate Moderate	High High High	Low Low Low	0.32 0.43 0.43	5	7
Moderate Moderate Moderate	Moderate Moderate Moderate	Moderate Moderate Moderate	0.28 0.28 0.37	5	6
Moderate High Moderate	High High High	Moderate Moderate Moderate	0.32 0.32 0.32	3	6
Moderate Moderate Moderate	Moderate Moderate Moderate	Moderate Moderate Moderate	0.28 0.28 0.37	5	6
Moderate High Moderate	High High High	Moderate Moderate Moderate	0.32 0.32 0.32	3	6

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
[1] 93E2:				
Shelby part	0–10	0.6–2.0	0.20–0.22	5.6–6.0
	10–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–60	0.2–0.6	0.16–0.18	6.6–7.8
Adair part	0–26	0.2–0.6	0.17–0.19	5.6–6.5
	26–42	0.06–0.2	0.13–0.16	5.1–6.5
	42–60	0.2–0.6	0.14–0.16	5.6–6.5
Marshall:				
99C, 99C2, 99D, 99D2	0–11	0.6–2.0	0.21–0.23	5.6–6.5
	11–60	0.6–2.0	0.18–0.20	5.6–7.3
Colo:				
133	0–29	0.2–0.6	0.21–0.23	5.6–6.5
	29–60	0.2–0.6	0.18–0.20	6.1–7.3
133+	0–15	0.6–2.0	0.22–0.24	6.6–8.4
	15–29	0.2–0.6	0.18–0.20	6.1–7.3
Wabash:				
172	0–15	<0.06	0.12–0.14	5.6–7.3
	15–60	<0.06	0.08–0.12	5.6–7.8
Gara:				
179D, 179D2, 179E2, 179F2, 179G2	0–12	0.6–2.0	0.20–0.22	5.6–6.0
	12–46	0.2–0.6	0.16–0.18	5.1–6.5
	46–60	0.2–0.6	0.16–0.18	6.6–7.8
Adair:				
192C, 192C2, 192D, 192D2	0–26	0.2–0.6	0.17–0.19	5.6–6.5
	26–42	0.06–0.2	0.13–0.16	5.1–6.5
	42–60	0.2–0.6	0.14–0.16	5.6–6.5
Kennebec:				
212	0–45	0.6–2.0	0.22–0.24	5.6–6.5
	45–60	0.6–2.0	0.20–0.22	6.1–7.3
Nodaway:				
220	0–60	0.6–2.0	0.20–0.23	6.1–7.3
Wabash:				
248, 248+	0–15	0.06–0.2	0.21–0.24	5.6–7.3
	15–60	<0.06	0.08–0.12	5.6–7.8
Olmitz:				
273B, 273C	0–21	0.6–2.0	0.19–0.21	5.6–6.5
	21–60	0.2–2.0	0.15–0.17	5.1–6.5
Minden:				
T299	0–22	0.6–2.0	0.21–0.23	5.6–6.5
	22–46	0.6–2.0	0.18–0.20	5.6–7.3
	46–60	0.6–2.0	0.20–0.22	5.6–7.3
Macksburg:				
T368	0–22	0.6–2.0	0.21–0.23	5.1–6.5
	22–42	0.2–0.6	0.18–0.20	5.1–6.0
	42–60	0.2–0.6	0.18–0.20	5.6–6.5
Winterset:				
T369	0–24	0.2–0.6	0.21–0.23	5.6–7.3
	24–31	0.06–0.6	0.14–0.18	5.6–6.5
	31–60	0.2–0.6	0.18–0.20	6.1–7.3
Sharpsburg:				
370, 370B, 370B2, 370C, 370C2, 370D, 370D2, T370B, T370C	0–16	0.6–2.0	0.21–0.23	5.1–6.5
	16–34	0.2–0.6	0.18–0.20	5.1–6.0
	34–60	0.2–0.6	0.18–0.20	6.1–6.5

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Moderate	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	Moderate	Moderate	0.37		
Moderate	High	Moderate	0.32	3	6
High	High	Moderate	0.32		
Moderate	High	Moderate	0.32		
Moderate	Moderate	Moderate	0.32	5	7
Moderate	Moderate	Low	0.43		
High	High	Moderate	---	---	7
High	High	Moderate	---		
Moderate	High	Low	---	---	6
High	High	Moderate	---		
Very high	High	Moderate	---	---	4
Very high	High	Moderate	---		
Moderate	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	Moderate	Moderate	0.37		
Moderate	High	Moderate	0.32	3	6
High	High	Moderate	0.32		
Moderate	High	Moderate	0.32		
Moderate	Moderate	Low	0.32	5	6
Moderate	Moderate	Low	0.43		
Moderate	Moderate	Low	---	---	7
High	High	Moderate	---	---	4
Very high	High	Moderate	---		
Moderate	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	High	Moderate	---	---	7
Moderate	High	Low	---		
Moderate	High	Low	---		
Moderate	High	Moderate	0.32	5	6
High	High	Moderate	0.43		
High	High	Moderate	0.43		
Moderate	High	Moderate	---	---	7
High	High	Moderate	---		
High	High	Low	---		
Moderate	Moderate	Moderate	0.32	5	7
High	Moderate	Moderate	0.43		
Moderate	Moderate	Low	0.43		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
Mayberry:				
692C2, 692D, 692D2	0–10	0.2–0.6	0.17–0.19	5.6–6.0
	10–46	0.06–0.2	0.10–0.11	5.6–7.3
	46–60	------------	------------	------------
Alluvial land, sandy:				
715	0–60	------------	------------	------------
Northboro:				
751C, 751C2, 751D, 751D2	0–14	0.6–2.0	0.18–0.22	5.6–6.5
	14–40	0.6–2.0	0.17–0.21	5.6–6.5
	40–60	0.2–0.6	0.12–0.16	6.1–7.3

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and

heterogeneous mixture that shows little evidence of sorting or stratification. This till contains pebbles, boulders, and sand as well as silt and clay. The mineral composition of its components is also heterogeneous (*7*) and is similar to that of the particles in unweathered loess.

Soils formed on the Kansan till plain during the Yarmouth and Sangamon Interglacial Stages before the loess was deposited. In nearly level areas the soils are strongly weathered and have a gray clay subsoil called "gumbotil" (*6, 23*). This gumbotil is several feet thick and has very slow permeability. The only primary minerals remaining in these strongly weathered soils are those most resistant to weathering. Soils that formed on the more sloping parts of the Kansan till plain were less strongly weathered, more reddish, and not so thick as those in level areas. These more sloping soils formed during the Sangamon Interglacial Stage. They have pebbles or a stone line in the upper part of the subsoil in some places (*12*).

The soils that formed during the Yarmouth and Sangamon ages were covered by loess during the Wisconsin age. They are called paleosols. Several studies of buried soils have been made (*10, 14, 16, 17, 18, 19*). In one of these studies, it was concluded that the buried soils had been altered by bases that had leached from the overlying materials and resaturated the buried soils (*18*). Geologic erosion has removed the loess from many side slopes and most of the strongly weathered gray paleosols. The glacial till that remains is either exhumed reddish paleosol or relatively unweathered glacial till.

The parent material of soils recently derived from glacial till ranges from strongly weathered paleosols to relatively unweathered till. The soils that developed from the strongly weathered gray paleosols are not extensive in Page County. In places where these soils occur, they are represented by gray clay spot symbols. Adair soils formed in the reddish paleosols. Mayberry and Northboro soils are presumed to have formed in alluvial sediment from the reddish paleosols mixed with loess. Shelby and Gara soils formed in unweathered or only slightly weathered Kansan till from which the overlying paleosols and loess were removed by geologic erosion.

Alluvium is one of the extensive parent materials in Page County. It consists of sediment laid down along major streams and narrow upland drainageways and on low benches. The texture of the alluvium varies widely because it came from different materials and was deposited at different times.

Some of the alluvial material has been transported only short distances and is called local alluvium. Such alluvium retains many of the characteristics of the soils from which it was washed. Judson soils, for example, generally are at the base of slopes below soils that formed in loess. The material in which they formed washed or rolled down the slope. Judson soils generally are silty clay loam as are loess-derived soils.

Nodaway soils formed in recent alluvium and are silt loam. Kennebec, Colo, Zook, and Wabash soils, which are listed in order of increasingly finer textures, formed in alluvium consisting of local sediment washed from nearby uplands and intermixed with sediment that washed from greater distances. These soils are older and darker than Nodaway soils. Bremer and Nevin soils formed in still older alluvium. These soils are above the level of the present flood plain or low benches. They are either silty or clayey depending on the source of the alluvium or on the way the material was sorted or deposited by the floodwater.

Windblown sand is not an extensive parent material in Page County. It occurs on upland slopes and benches near the Nishnabotna and Nodaway Rivers. This sandy material is believed to have originated in valleys of these rivers in the Late Wisconsin period. Later it was windblown onto slopes along the rivers.

Windblown sand consists mainly of quartz, which is very resistant to weathering. It has not been altered much since it was deposited. Sparta soils, the only soils in this county that formed in windblown sand, have a low content of clay.

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Moderate	High	Low	0.32	3	4
High	High	Low	0.32		
					2
Moderate	Moderate	Moderate	0.32	5	7
Moderate	Moderate	Moderate	0.43		
Moderate	Moderate	Moderate	0.43		

behavior characteristics of the mapping unit.

Climate

According to recent evidence, Page County soils formed under variable climatic conditions. In the post-Cary glaciation period, 10,500 to 13,000 years ago, the climate of southwest Iowa was cool and the vegetation was dominated by conifers (*22*). A warming trend occurred 8,000 to 10,500 years ago, and the vegetation changed from conifers to hardwood species. Beginning about 8,000 years ago, as the climate became warmer and drier the herbaceous prairie vegetation became dominant. Studies of this forest-prairie transition in central Iowa (*8*) indicate that there was a late change in the post-glacial climate from relatively dry prairie to more moist conditions. This change may have begun about 3,000 years ago. The present climate is midcontinental subhumid.

Nearly uniform climate prevails throughout the county, but it is modified by local conditions. For example, on steep hillsides most of the water runs off or soaks rapidly into the soil. This results in a warmer and drier climate than that of less sloping areas. On south-facing slopes the effect is similar. North- and east-facing slopes tend to be cooler and more moist than south-facing slopes. Low-lying or depressional, poorly drained or very poorly drained soils are wetter and colder than the surrounding soils.

The general climate has had an important overall influence on the characteristics of the soils of the county, but has not caused significant differences among them. The local climate, however, has influenced soil characteristics sufficiently to account for some of the differences among soils within the same climatic region.

Temperature changes activate weathering of the parent material by water and air. This weathering of the parent material consists of both physical and chemical actions. Rainfall has influenced the formation of soils through its effect on the amount of leaching in soils and on the natural selection of plants.

Some variations in plant and animal life are caused by variations in temperature or by the action of other climatic forces on the soil material. To that extent climate influences those changes in soil that are brought about by differences in plant and animal populations.

Plant and animal life

Many kinds of living organisms are important in soil development. For example, the activities of burrowing animals, worms, crayfish, and micro-organisms are reflected in soil properties. But differences in the kind of vegetation commonly cause the most marked differences among soils (*9*).

In Page County tall grasses were the dominant vegetation at the time of settlement. There were about 51,200 acres of trees (*4*), which were mainly in steep areas near the major streams and on the flood plains. Most of the thickest stands of timber on the uplands are on north- and east-facing slopes. The dominant kinds of plant life have changed with time.

Because grasses have many roots and tops that have decayed or are in the soil, soils that formed under prairie typically have a thicker, darker surface layer than soils that formed under trees. In soils that formed under trees, the organic matter was derived principally from leaves and was deposited mainly on the surface of the soil. Marshall and Shelby soils are typical soils that formed under prairie. Ladoga and Gara soils, which have properties intermediate between soils that formed entirely under trees and those that formed under grass, are believed to have developed first under prairie grasses and then later under trees. These are the only soils in the county that have been markedly influenced by trees. In other places the stands of trees have not been in place long enough to influence the soils to the extent that a different soil series can be recognized and mapped.

Man has markedly influenced soils by his use of them. Soil changes caused by water erosion as a result of tillage practices are often the most apparent.

TABLE 12.—*Soil and water features*

[The definitions of "flooding" and "water table" in the Glossary explain the terms "brief," "apparent," and "perched." The symbol > means more than. Dashes indicate that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			High water table			Depth to bedrock	Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months		
					Ft			*In*	
Judson: 8B	B	None	---	---	>6.0	---	---	>60	High.
Marshall: 9B, 9B2, 9C, 9C2, T9, T9B	B	None	---	---	>6.0	---	---	>60	High.
Colo: [1] 11B:									
Colo part	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	>60	High.
Judson part	B	None	---	---	>6.0	---	---	>60	High.
Shelby: 24D, 24D2, 24E, 24E2, 24F2	B	None	---	---	>6.0	---	---	>60	Moderate.
Sparta: 41D	A	None	---	---	>6.0	---	---	>60	Low.
Bremer: 43	C	Rare to common.	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	>60	High.
Zook: 54, 54+	C/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	>60	High.
Ladoga: 76B, 76C, 76C2, 76D, 76D2	B	None	---	---	>6.0	---	---	>60	High.
Nevin: 88	C	Rare to occasional.	Very brief	Feb-Nov	3.0–5.0	Perched	Nov-Jun	>60	High.
Shelby: [1] 93D:									
Shelby part	B	None	---	---	>6.0	---	---	>60	Moderate.
Adair part	D	None	---	---	1.0–3.0	Perched	Nov-Jun	>60	High.
[1] 93D2:									
Shelby part	B	None	---	---	>6.0	---	---	>60	Moderate.
Adair part	D	None	---	---	1.0–3.0	Perched	Nov-Jun	>60	High.
[1] 93E2:									
Shelby part	B	None	---	---	>6.0	---	---	>60	Moderate.
Adair part	D	None	---	---	1.0–3.0	Perched	Nov-Jun	>60	High.
Marshall: 99C, 99C2, 99D, 99D2	B	None	---	---	>6.0	---	---	>60	High.
Colo: 133, 133+	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	>60	High.
Wabash: 172	D	Common	Brief to long.	Feb-Nov	0–1.0	Perched	Nov-Jun	>60	Moderate.
Gara: 179D, 179D2, 179E2, 179F2, 179G2	C	None	---	---	>6.0	---	---	>60	Moderate.

TABLE 12.—*Soil and water features*—Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Depth to bedrock	Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months		
					Ft			*In*	
Adair: 192C, 192C2, 192D, 192D2	D	None			1.0–3.0	Perched	Nov-Jun	>60	High.
Kennebec: 212	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	>60	High.
Nodaway: 220	B	Common	Brief	Feb-Nov	>6.0			>60	High.
Wabash: 248, 248+	D	Common	Brief to long.	Feb-Nov	0–1.0	Perched	Nov-Jun	>60	Moderate.
Olmitz: 273B, 273C	B	None to rare.			>6.0			>60	Moderate.
Minden: T299	B	None			3.0–5.0	Perched	Nov-Jun	>60	High.
Macksburg: T368	B	None			2.0–4.0	Perched	Nov-Jun	>60	High.
Winterset: T369	C	None			0–3.0	Perched	Nov-Jun	>60	High.
Sharpsburg: 370, 370B, 370B2, 370C, 370C2, 370D, 370D2, T370B, T370C	B	None			>6.0			>60	High.
Mayberry: 692C2, 692D, 692D2	D	None			>6.0			>60	High.
Alluvial land, sandy: 715	B	Frequent	Brief	Feb-Nov	0–4.0	Apparent	Nov-Jun	>60	Moderate.
Northboro: 751C, 751C2, 751D, 751D2	C	None			>6.0			>60	High.

[1] This mapping unit is made up of two or more dominant kinds of soil. See mapping unit description for the composition and behavior characteristics of the mapping unit.

For example, on many of the cultivated soils in the county, much of the original surface layer has been lost through sheet erosion, and in some places gullies have formed. Tillage alters the structure of the surface soil. Less obvious are chemical changes in the soil that are brought about by addition of lime and fertilizers, and changes in microbial activity and organic-matter content brought about by removing the native vegetation and substituting crops.

Relief

Relief, or topography, refers to the lay of the land. It ranges from nearly level to very steep in Page County. Relief is an important factor in soil formation because of its effect on drainage, runoff, height of the water table, and erosion. Some soils, such as the nearly level Macksburg soils and the sloping Sharpsburg soils, differ mainly because they formed on different positions on the landscape.

Even in soils that formed in the same parent material, the influence of relief is seen in color, thickness of solum, and development of horizons. On the steeper slopes there is more runoff, consequently the soil erodes so fast that little horizonation can take place. On the more nearly level slopes where most of the water soaks in, there is less runoff and less erosion. The infiltrating water also leaches the more soluble minerals to a greater depth. Thus, soils that have developed in the steeper areas tend to have a thinner surface layer and to be calcareous nearer the surface, but soils that have developed in the more level areas tend to have a thicker surface layer and have carbonates at a greater depth.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. In soils that have good drainage, the subsoil generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. For example, Judson soils at slightly higher elevations are well drained to moderately well drained and have a brownish subsoil. In soils that have restricted drainage, the subsoil generally is grayish and mottled. For example, the low-lying, very poorly drained Wabash and Zook soils on bottom land have a grayish subsoil.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to change the parent material. Similar kinds of soils are produced from widely different kinds of parent material if the other factors of soil formation continue to prevail over long periods of time. Geologic events that expose new parent material generally interrupt soil development.

In Page County the bedrock has been covered by glacial drift from two different glaciers, the Nebraskan and the Kansan. Later, the present surface material, the Wisconsin loess, was deposited over the till. As a result, soils have been buried and they stopped developing.

The oldest soils in the county are shown on the soil map by the spot symbol for gray clay. They formed in till that weathered for perhaps 450,000 years during the Yarmouth and Sangamon interglacial ages (*7*). This till was covered by loess during the Early Wisconsin age (*14*). More recently the till was exposed to weathering again when the loess was removed by erosion. Because of long periods of weathering, these soils have a fine textured B horizon 3 to 8 feet thick.

Adair soils have a history of formation similar to that of the soils that formed in the gray paleosol, but they probably weathered for only 115,000 years before they were covered by loess. Additional weathering has taken place since the loess was removed. Adair soils are old, but they are younger than the soils that formed in the gray paleosol. The B horizon of the Adair soils is 2 to 4 feet thick and is moderately fine to fine textured.

Like Adair soils, Shelby soils formed in glacial till. They have weathered, however, only during the Late Wisconsin and Holocene times, or for a period of about 14,500 years. The B horizon of Shelby soils is 1½ to 3 feet thick and is moderately fine textured.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating Late Pleistocene material (*11, 14*). Loess deposition began about 25,000 years ago and continued to about 14,000 years ago, hence the surface of the nearly level loess-mantled divides in Iowa is about 14,000 years old. In Page County, these stable areas include the nearly level ridgetops, divides, and benches and the less sloping parts of gently sloping ridgetops that are occupied mainly by Marshall and Sharpsburg soils. In much of Iowa, including Page County, geologic erosion has leveled and, in places, removed material on side slopes and deposited new sediment downslope (*16*). The surface of the nearly level upland divides is older than the slopes that bevel and ascend to the divides. Thus, the side slopes are less than 14,000 years old.

The sediment stripped from side slopes accumulated to form local alluvium, and the age of the side slopes is determined by the age of the alluvial fill at the base. In some stream valleys in western Iowa this alluvium was found to be less than 1,800 years old (*3*). In Adair County in southwest Iowa the base of the alluvial fill was about 6,800 years old (*16*). Because sediment was removed from the side slopes to form the alluvium, the side slopes in these areas have a surface that is as young or younger than the alluvium. Some of the soils that have formed in similar material in Page County are the Judson, Olmitz, and Kennebec soils.

Classification of the soils

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Readers interested in further details about the system should refer to "Soil taxonomy" (*21*).

The system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the classification is based on the different soil properties that can be observed in the field or those that can be inferred either from other properties that are observable in the field or from the combined data of soil science and other disciplines. The properties selected for the higher categories are the result of soil genesis or of factors that affect soil genesis.

Table 13 shows the classification of each soil series of Page County according to the current system. The categories of the system are described in the following paragraphs.

ORDER—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate among orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates. The three orders in Page County are Entisols, Mollisols, and Alfisols.

Entisols are light colored soils that do not have natural genetic horizons or that have only weakly expressed beginnings of such horizons. These soils have not been mixed by shrinking and swelling.

Mollisols formed under grass and have a thick, dark colored surface horizon containing colloids dominated by divalent cations. These soils have not been mixed by shrinking and swelling.

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

SUBORDER—Each order is divided into suborders primarily on the basis of those soil characteristics that seem to produce classes having 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

TABLE 13.—*Classification of the soils*

Soil name	Family or higher taxonomic class
Adair	Fine, montmorillonitic, mesic Aquic Argiudolls
Alluvial land, sandy	Fluvaquents
Bremer	Fine, montmorillonitic, mesic Typic Argiaquolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Gara	Fine-loamy, mixed, mesic Mollic Hapludalfs
Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
Kennebec	Fine-silty, mixed, mesic Cumulic Hapludolls
Ladoga	Fine, montmorillonitic, mesic Mollic Hapludalfs
Macksburg	Fine, montmorillonitic, mesic Aquic Argiudolls
Marshall	Fine-silty, mixed, mesic Typic Hapludolls
Mayberry	Fine, montmorillonitic, mesic Aquic Argiudolls
Minden	Fine-silty, mixed, mesic Aquic Hapludolls
Nevin	Fine-silty, mixed, mesic Aquic Argiudolls
Nodaway	Fine-silty, mixed, nonacid, mesic Mollic Udifluvents
Northboro	Fine-silty, mixed, mesic Typic Hapludolls
Olmitz	Fine-loamy, mixed, mesic Cumulic Hapludolls
Sharpsburg	Fine, montmorillonitic, mesic Typic Argiudolls
Shelby	Fine-loamy, mixed, mesic Typic Argiudolls
Sparta	Sandy, mixed, mesic Entic Hapludolls
Wabash	Fine, montmorillonitic, mesic Vertic Haplaquolls
Winterset	Fine, montmorillonitic, mesic Typic Argiaquolls
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP—Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus has accumulated or those that have pans that interfere with the growth of roots or movement of water. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The names of great groups consist of the name of a suborder and a prefix that suggests something about the properties of the soil.

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

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

Processes of horizon differentiation

The age of a soil is determined by the degree of horizon development, or differentiation, in the profile. Horizon differentiation is caused by four basic kinds of changes: additions, removals, transfers, and transformations. Each of these changes affects many substances that make up a soil. For example, there can be additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals.

In general, these processes tend to promote horizon differentiation, but others offset or retard it. These processes, and the changes they make, act simultaneously in soils, and the balance of those changes within the profile governs the ultimate nature of the profile.

Addition of organic matter is an early step in the process of horizon differentiation in most soils. In Page County most of the soils have developed a fairly deep, dark colored surface horizon as a result of the accumulation of organic matter. Nodaway soils, however, have a thin surface layer that is moderately dark colored. They are at an early stage of development, so appreciable amounts of organic matter have not accumulated.

The process of removing substances from parts of the soil profile is important in the differentiation of horizons. The movement of calcium carbonate downward in the soil material as a result of leaching is an example. Soils in which the calcium carbonate has been removed from the upper layers reflect a more advanced stage of development than soils that have this substance at or near the surface. The soils of Page County have very little calcium carbonate in the upper horizons.

Many kinds of transfers of substances from one horizon to another are evident in the soils of Page County. For example, phosphorus is removed from the subsoil by plant roots, transferred to parts of the plant above the ground, and then returned to the surface layer in the form of plant residue.

The translocation of silicate clay minerals is an important process in horizon differentiation. The clay minerals are carried downward in suspension in percolating water from the A horizon. They accumulate in the B horizon in pores and root channels and as clay films on ped faces. This process has had a marked effect on the profiles of Adair, Bremer, Mayberry, Macksburg, Nevin, Shelby, Sharpsburg, and Winterset soils. These soils have a higher clay content in the B horizon than in the A or C horizons, and clay films generally can be seen in the B horizon.

Another kind of transfer is caused by the shrinking and swelling of soils, which cause cracks to form. Material from the surface layer falls into these cracks and is incorporated into the lower part of the profile. This type of movement is minimal in most soils, but in clayey soils, such as those of the Wabash and Zook soils, considerable amounts of material may be transferred.

Transformation can be both physical and chemical, as, for example, in the weathering of soil particles to smaller sizes and the reduction of iron in a saturated soil. The latter process is called "gleying" and involves the saturation of the soil with water for long periods in the presence of organic matter. It is characterized by the presence of gray colors. Gleying is associated with poorly drained and very poorly drained soils such as Wabash and Zook soils.

General nature of the county

This section discusses the history, drainage and topography, climate, and agriculture of Page County.

History

The area that is now Page County was occupied in the early 1800's by Indians of the Sac, Fox, and Pottawatomie tribes. The county was settled by people from Missouri in 1841, and by 1850 there were 150 people living in the area.

The county was named after Captain John Page, a hero of the Mexican War. The first town was established in 1855 and was called Hawleyville. The town of Clarinda was established in 1857 and was the first county seat. The first railroad in the county was completed in 1871. The town of Shenandoah was established in 1870.

By 1885 the population of Page County was 20,938. Most of the people were engaged in farming. The farmers raised mostly cereal grain, but by 1890 the raising of livestock was becoming important. The nursery stock industry was established in the early 1900's. The national 4-H club movement originated in Page County in 1908 as an agricultural club for boys.

The population of Page County was 18,507 in 1970; 14,691 people lived in towns. The two largest towns are Shenandoah and Clarinda with populations of 5,968 and 5,420. The towns of Essex, Coin, Northboro, College Springs, and Braddyville each have a population of about 500 or less.

Drainage and topography

Page County is mainly drained by the East Nishnabotna River, Tarkio River, East and West Tarkio Creeks, and the East Nodaway and Nodaway Rivers. Some of the important smaller streams are Buchanan Creek, Fisher Creek, Mill Creek, Neele Branch, Pierce Creek, Rocky Branch, Snake Creek, and Walnut Creek. These streams drain to the south. The bottom lands and narrow drainageways on the uplands mainly need artificial drainage.

The topography of Page County generally is rolling. The uplands consist of smooth and rounded hills that have even slopes and are cut by various streams, tributaries, and intermittent drainageways. The uplands near the rivers and main streams have steeper, more abrupt slopes, and the hills are more narrow and less rounded.

The benches, or second bottom lands, which are in the valleys of the Nodaway, East Nodaway, and East Nishnabotna Rivers are nearly level to gently sloping. They generally are a quarter of a mile to 1 mile wide. The first bottom lands are nearly level, and along the major streams they are 1 to 2 miles wide.

Agriculture

In this section, farming in Page County is discussed. Unless otherwise stated, all the information is from the 1970 edition of the Iowa Annual Farm Census.

Farms and farm tenure

In 1970 Page County had 1,283 farms. The total acreage was 334,452 acres, and the average size of a farm was 261 acres. About one half of the farms were farmed by the owners, although the trend has been toward larger farms and fewer operators.

Crops and pasture

In 1970, 182,147 acres were in cropland. Of that acreage, 93,345 acres were in corn, 53,838 acres in soybeans, 24,053 acres in hay, and less than 11,000 acres in small grains.

Row crops generally are grown in rotation with hay and pasture, but they are mostly grown in some of the less sloping areas that are not subject to serious erosion.

In 1970, 93,699 acres in the county were used as pasture. Much of that acreage was improved pasture seeded to mixtures of grasses and legumes, most commonly alfalfa and bromegrass or orchardgrass. Some pastures are in bluegrass, and most of the woodlands are grazed.

Livestock

Raising and feeding beef cattle and hogs are the major livestock enterprises in Page County. In 1970, 39,599 grain-fed cattle and 180,403 hogs were marketed. There were 17,071 beef cows, 1,312 dairy cows, and 32,083 laying hens in the county, and 24,424 litters of hogs were farrowed. There were 1,276 lambs born, and 1,336 grain-fed sheep and lambs marketed.

The number of beef cows and grain-fed cattle has increased since 1960, but grain-fed cattle have decreased slightly in recent years. The number of hogs has been fairly stable. The number of dairy cattle, sheep, and poultry has decreased steadily.

Climate

Page County weather data in tables 14 and 15 are from Clarinda. Annual precipitation at Clarinda is 31.7 inches. It ranges from slightly more than 31 inches in the northwestern corner of the county to almost 33 inches in the southeastern corner. Much of the precipitation occurs in the warm season months. The wettest month is June, and the second wettest is August. Precipitation extremes from each month (1 year in 10) are given in table 14. During the 1951-60 period, Clarinda averaged 21 days per year with half an inch or more of rainfall and 58 days with 0.10 inch or more.

Most of the heavy showers occur during the warm part of the year. About 75 percent of the annual precipitation occurs as showers in April through September. Individual showers may vary widely in intensity throughout the county. One inch or more of rainfall in a 1-week period is probable in about 4 years out of 10 in June and in about 2 years out of 10 in July and

TABLE 14.—*Temperature and precipitation*

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly maximum	Average monthly minimum	Average monthly total	1 year in 10 will have— Less than—	1 year in 10 will have— More than—	Days with snow cover 1.0 in. or more	Average depth of snow on days with snow cover
	°F	*°F*	*°F*	*°F*	*In*	*In*	*In*	*No*	*In*
January	33	13	55	−14	1.0	0.2	1.6	17	4
February	37	16	60	−6	1.0	0.2	2.1	11	3
March	49	27	74	4	2.1	0.7	4.7	6	6
April	64	39	85	22	2.4	0.7	5.8		1
May	74	50	89	33	3.8	1.7	7.7		
June	83	60	93	45	5.5	2.1	9.6		
July	89	64	99	52	3.2	1.2	7.6		
August	87	62	96	48	4.6	1.2	7.6		
September	79	53	92	33	3.4	1.2	7.6		
October	67	42	84	24	2.1	0.3	4.7		
November	50	28	72	9	1.7	0.5	2.8	3	2
December	37	17	59	−6	0.9	0.1	1.7	8	4
Year	62	39	99	−17	31.7	25.5	43.7	45	4

TABLE 15.—*Probabilities of last freezing temperatures in spring and first in fall*

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	Apr. 6	Apr. 10	Apr. 21	May 2	May 13
2 years in 10 later than	Mar. 31	Apr. 5	Apr. 16	Apr. 27	May 8
5 years in 10 later than	Mar. 21	Mar. 25	Apr. 5	Apr. 17	Apr. 28
Fall:					
1 year in 10 earlier than	Oct. 30	Oct. 22	Oct. 11	Oct. 4	Sept. 24
2 years in 10 earlier than	Nov. 4	Oct. 27	Oct. 17	Oct. 9	Sept. 29
5 years in 10 earlier than	Nov. 15	Nov. 7	Oct. 28	Oct. 20	Oct. 9

August. Well developed crops use more than an inch of water a week in summer.

The Clarinda temperature data is representative of Page County, particularly maximum temperatures. The maximum temperature is 90° F. or higher on an average of 36 days a year. These temperatures are too high for optimum crop production because crops require a greater amount of water on such days. Minimum temperatures tend to vary more than maximum temperatures. Low areas generally have minimum temperatures on clear, calm nights that are lower than those of the urban and upland areas.

Freezing-temperature data for Clarinda are given in table 15. The average date of the last 32° F. temperature in spring is April 28, and the average date of the first 32° temperature in fall is Oct. 9, giving a frost-free period of 164 days.

Soil moisture reserves are an important part of the moisture supply for crops. A 5-inch reserve early in spring is considered as critically low. In Page County there is a 20 percent chance that the upper 5 feet of soil will have less than 5 inches of available water for plants on April 15. The average for this time of year is 7.6 inches, but there is a 35 percent chance that the soil will have more than 9 inches.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bench position. A high, shelflike position. Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Bottom, first. The normal flood plain of a stream; land along the stream subject to overflow.

Bottom, second. An old alluvial plain, generally flat or smooth, that borders a stream but is seldom flooded.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or mangesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil materials that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Complex, soil. A mapping unit of two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map at the selected scale of mapping and publication.

Concretion. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

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

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

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

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

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

Cemented.—Hard; little affected by moistening.

Contour stripcropping (or contour farming). Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslopes areas by diverting runoff from its natural course.

Drainage, soil. This term refers to the natural drainage condition of a soil before the drainage was changed through the use of artificial methods of removing excess moisture. It is evaluated by observing soil colors and by the experience of soil scientists. The terms used to express the various degrees of natural drainage are: excessively drained, somewhat excessively drained, well drained, moderately well drained, imperfectly drained, poorly drained, and very poorly drained.

Drainage, surface. Runoff, or surface flow of water, from an area.

Flooding. The temporary covering of soil with water from overflowing streams, runoff from adjacent slopes, and tides. Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. None means that flooding is not probable; rare that it is unlikely but possible under unusual weather conditions; occasional that it occurs on an average of once or less in 2 years; and frequent that it occurs on an average of more than once in 2 years. Duration is expressed as brief if less than 2 days, brief if 2 to 7 days, and long if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May. Water standing for short periods after rainfall or commonly covering swamps and marshes is not considered flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial till (geology). Gravel, sand, and silt, commonly stratified, deposited by melt water as it flows from glacial ice. Grassed waterway. A natural of constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Gumbotil. Leached deoxidized clay containing siliceous stones; the product of thorough chemical decomposition of clay-rich till.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

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 a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Leaching. The removal of soluble material from soil or other material by percolating water.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

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

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

Paleosol. An antiquated soil that was formed during the geologic past and was buried and preserved by more recent sedimentation. This kind of buried soil is commonly re-exposed on the modern surface by subsequent erosion. It then occurs within the continuum of soils on the modern surface and is called an exhumed paleosol.

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedisediment. A sediment that covers a pediment rather thinly. A pediment is an erosion surface that lies at the foot of a receded slope, is underlain by rocks or sediment of the upland, is barren or mantled with alluvium, and displays a longitudinal profile, normally concave upward.

pH value. (See **Reaction, soil**). A numerical designation of acidity and alkalinity in soil.

Profile, soil. A vertical section of the soil extending through all its horizons and 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 described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	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

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Seepage. The rapid movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils, formed from a particular type of parent material, having horizons that, except for the texture of the A or surface horizon, are similar in all profile characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

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

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

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

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

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

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 can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has 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, silt loam, 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."

Tile drainage. The process in which a concrete or ceramic pipe is placed at suitable depths and spacings in the soil or subsoil to provide water outlets from the soil.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the levels at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

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