SOIL SURVEY OF

Union County, Iowa

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
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 1969-72. Soil names and descriptions were approved in 1973. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service, the 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 Union Soil and Water Conservation District. Funds appropriated by Union County were used to pay part of the cost of the survey.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

The "Index to Map Units" on page ii can be used to find information in the survey. It lists all the soils in the county in numerical order by map symbol and shows the page where each soil is described. The capability unit to which each soil has been assigned is specified at the end of the soil description.

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

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

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

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

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

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

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers in Union County may be especially interested in the section "General Soil Map" where broad patterns of soils are described.

Cover picture: Typical landscape in Gara-Ladoga association showing good conservation practices. Ladoga soils are on the ridgetops and Armstrong and Gara soils are mainly on the side slopes.

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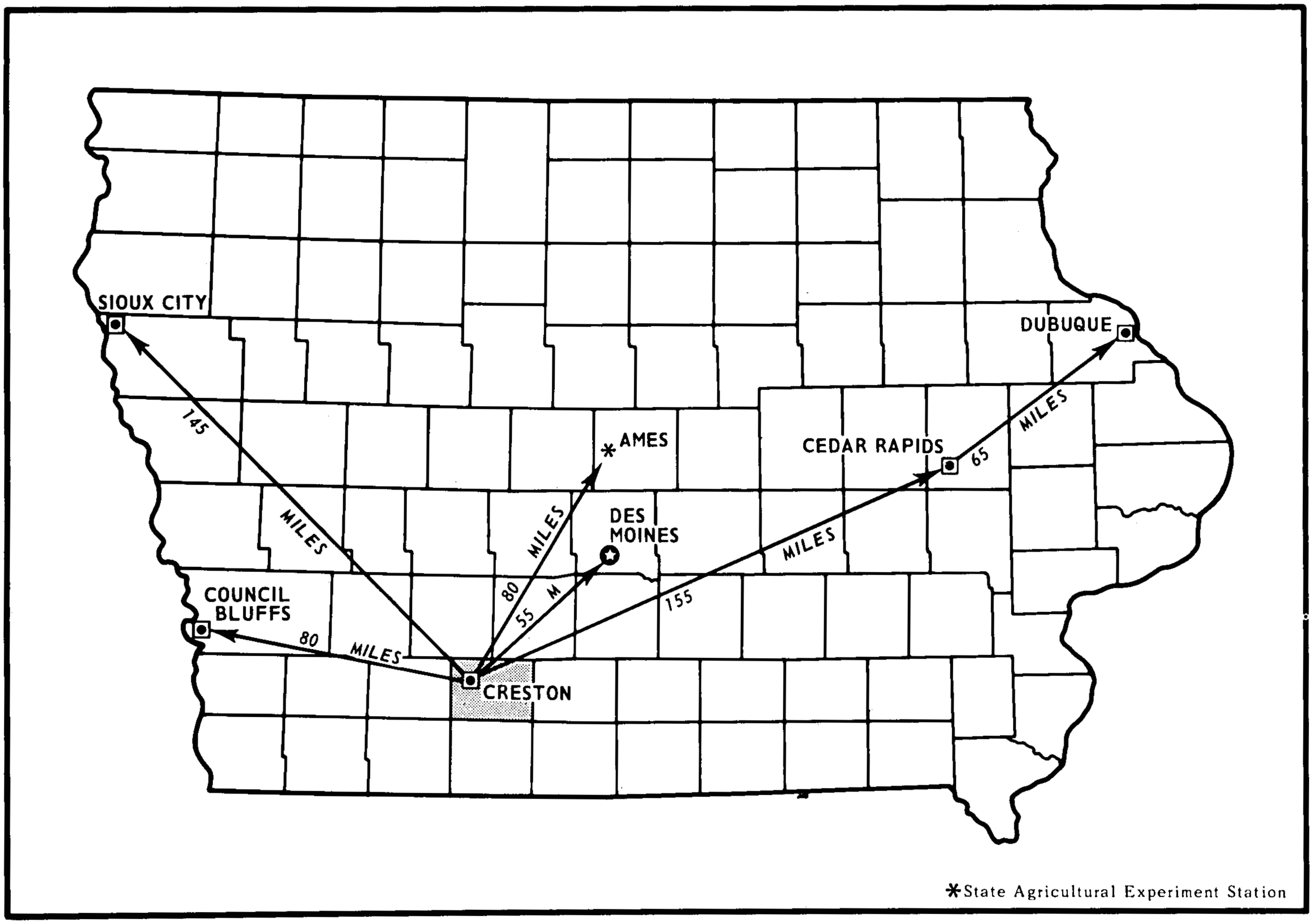

Location of Union County in Iowa.

SOIL SURVEY OF UNION COUNTY, IOWA

By John R. Nixon and Louis E. Boeckman

Fieldwork by John R. Nixon, Louis E. Boeckman, and Brian C. Peterson, 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 Department of Soil Conservation, State of Iowa

UNION COUNTY is in the southwestern part of Iowa (see facing page). It is the second county north of the State of Missouri and the fourth county east of the Missouri River. It has a total land area of about 425 square miles, or 272,000 acres. Creston, the county seat, is about 55 airline 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 is fed to livestock.

Most soils of Union County formed under prairie vegetation. Some formed under timber vegetation. The climate is subhumid and continental. Winters are cold, and summers are warm. The growing season is long enough for crops to mature.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Union 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. As they traveled over the county, they observed steepness, length, and shape of slopes; size of streams; kinds of native plants or crops; kinds of rock, and many facts about the soils. They dug or bored 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 to the rock material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures. To use this survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Sharpsburg and Macksburg, 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 natural characteristics.

Many soil series contain soils that are alike except for texture of their surface layer. According to this difference in texture, separations called soil types are made. Within a series, all the soils having a surface layer in the same texture belong to one soil type. Wabash silty clay and Wabash silty clay loam are two soil types in the Wabash series. The difference in texture of their surface layers is apparent from their names.

Some soil types have a wide range of slope, degree of slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Shelby clay loam, 9 to 14 percent slopes, is one of several phases of Shelby clay loam, a soil type that ranges from sloping to steep.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew soil boundaries on aerial photographs. They used photos for their base map because they show woodlands, buildings, field borders, trees, and similar detail that greatly help in drawing boundaries accurately. The soil map at the back of this survey was prepared from the aerial photographs.

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

In preparing some detailed maps, the soil scientist has a problem of delineating areas where different kinds of soils are so intricately associated and so small in size that it is not practical to show them separately on the map. Therefore, he shows this mixture of soils as one mapping unit and calls it a soil complex. Ordinarily, a soil complex is named for the major soil series in it, for example, Colo-Ely silty clay loams.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, managers of woodland, engineers, and home owners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil surveys. The soil scientists set up trial groups based on the yield and practice tables and other data. 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 of their studies and consultation. Thus, the groups that are finally evolved reflect 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 Union County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern. The general soil map of Union County may not match the general soil maps of adjoining counties because more recent information about the soils was available when the Union County map was made.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for planning the management of a farm or field because the soils in any one association ordinarily differ in slope, depth, drainage or other characteristics that affect management. The seven soil associations in Union County are described in the following paragraphs.

1. *Macksburg-Winterset association*

Nearly level to gently sloping, somewhat poorly drained and poorly drained upland soils that are silty clay loam throughout and formed in loess

This soil association is mainly on uplands, on the wide nearly level ridgetops and the lower convex slopes. It is also in shallow depressional areas in the ridges.

This association makes up about 8 percent of the county. About 50 percent is Macksburg soils, 21 percent Winterset soils, and 29 percent minor soils.

The Macksburg soils, on broad nearly level to gently sloping divides, are somewhat poorly drained. The surface layer typically is black and very dark grayish brown silty clay loam about 22 inches thick. The subsoil is dark grayish brown grading to grayish brown. The subsoil is silty clay loam that extends to a depth of about 5 feet.

The Winterset soils, on broad nearly level upland divides, are poorly drained. The surface layer typically is black silty clay loam about 18 inches thick. The subsoil is very dark gray silty clay loam that extends to a depth of about 5 feet.

Minor in this association are the Sperry, Sharpsburg, Nira, and Clearfield soils. The very poorly drained Sperry soils, which have a lighter colored surface layer than Macksburg and Winterset soils, are in depressional areas on the nearly level divides. The moderately well drained Sharpsburg soils, which formed in loess, are on high upland convex divides and the upper side slopes adjacent to the broad nearly level divides of Macksburg and Winterset soils. Nira and Clearfield soils, which also formed in loess, are at the heads of drainageways and on the upper parts of convex side slopes.

The soils in this association are well suited to crops. Corn and soybeans are the major crops. Much of the corn is fed to livestock. Soybeans is a cash crop. Only a small part of this association is in pasture, generally the small acreages near farmsteads.

2. *Sharpsburg-Shelby-Nira association*

Gently sloping to moderately steep, moderately well drained and well drained upland soils that have a silty clay loam or clay loam surface layer and formed in glacial till or loess

This soil association is on ridgetops and divides, on side slopes, and in drainageways. It makes up about 52 percent of the county. About 19 percent is Sharpsburg soils (fig. 1), 18 percent Shelby soils, 16 percent Nira soils, and 47 percent minor soils.

The Sharpsburg soils, on high upland convex divides and upper side slopes adjacent to the broad nearly level divides of the Macksburg and Winterset soils, are moderately well drained. The surface layer typically is black to very dark grayish brown light silty clay loam about 13 inches thick. The subsoil is brown to yellowish brown grading to grayish brown. It is silty clay loam that extends to a depth of about 4 feet.

The Shelby soils, on convex side slopes and narrow ridgetops, are moderately well drained or well drained. The surface layer typically is black to very dark grayish brown clay loam about 15 inches thick. The subsoil is dark brown, dark yellowish brown, and brown clay loam that extends to a depth of about 38 inches.

The Nira soils, on short convex upland side slopes and slopes bordering drainageways, are moderately well drained. The surface layer typically is black to very dark gray silty clay loam about 13 inches thick. The subsoil is a relict mottled brown that reflects past drainage conditions. It extends to a depth of about 44 inches.

Figure 1.—**Typical landscape in Sharpsburg-Shelby-Nira association. Sharpsburg soils are on the ridgetops, Nira soils on upper side slopes and at the heads of drainageways, and Shelby soils on the steeper side slopes.**

Minor in this association are the Clearfield, Clarinda, Lamoni, Adair, Dickinson, Colo, and Ely soils. The poorly drained Clearfield soils, which formed in loess over weathered glacial till, are at the heads of drainageways, on narrow bands on side slopes, and on slopes adjacent to Sharpsburg and Nira soils. The poorly drained Clarinda soils are at the heads of drainageways, on narrow bands on side slopes, and on narrow upland convex ridges generally below Clearfield or Nira soils. The moderately well drained to somewhat poorly drained Adair soils are on convex ridgetops, commonly in bands at the shoulders of side slopes. The somewhat poorly drained Lamoni soils are at the moderately and strongly sloping heads of branching waterways, downslope from the Sharpsburg, Nira, and Clearfield soils. Many areas are adjacent to and downslope from the Clarinda soils. Other areas are upslope from the Shelby soils. The well drained Dickinson soils are on uplands along major streams and rivers. The poorly drained to somewhat poorly drained Colo and Ely soils are in drainageways.

The soils in this association have high available water capacity. Runoff is rapid in many areas, and erosion is moderate to severe. The contact zone between the loess and the glacial till is seasonally wet and seepy. Interceptor tile can alleviate the wetness. Terraces reduce erosion.

Row crops are grown on ridgetops and upper side slopes. The lower convex slopes are usually in meadow or permanent pasture.

3. Gara-Ladoga association

Gently sloping to steep, well drained and moderately well drained upland soils that have a loam or silt loam surface layer and formed in glacial till or loess

This soil association is along the major streams and tributaries on narrow, gently and moderately sloping ridgetops and strongly sloping to steep side slopes. It is generally covered with mixed timber and grass. Some areas have been recently cleared.

This association makes up about 10 percent of the county. About 32 percent is Gara soils, 25 percent Ladoga soils, and 43 percent minor soils.

The strongly sloping to steep Gara soils are on side slopes. They are well drained or moderately well drained. The surface layer typically is very dark gray loam about 7 inches thick. The subsurface layer typically is dark grayish brown loam about 5 inches thick. The subsoil is dark yellowish brown loam in the upper part. Below a depth of 17 inches, it is dark yellowish brown and yellowish brown clay loam. It extends to a depth of about 40 inches.

The gently sloping to moderately sloping Ladoga soils are on ridgetops. The strongly sloping Ladoga soils are on upper side slopes in the uplands and on stream benches along the Grand River. All are moderately well drained. They typically have a very dark gray silt loam surface layer about 7 inches thick. The subsurface layer, about 3 inches thick, is dark grayish brown and grayish brown silt loam that is distinctly light colored when dry. The subsoil, which extends to a depth of about 4 feet, is mainly brown and dark yellowish brown silty clay loam.

Minor in this association are the Armstrong, Lineville, Caleb, Mystic, Dickinson, and Lindley soils. The moderately well drained to somewhat poorly drained Armstrong soils formed in reddish colored late Sangamon paleosols on convex ridgetops and shoulders of ridgetops. The moderately well drained to somewhat poorly drained Lineville soils are on ridgetops, downslope from the Ladoga soils and upslope from the Armstrong soils. The moderately well drained Caleb soils formed in pre-Sangamon erosional sediments of glacial origin. The moderately well to somewhat poorly drained Mystic soils formed in Sangamon alluvium of mixed origin during late Sangamon time. Both Mystic and Caleb soils are on benches along major streams and tributaries. The moderately well drained, strongly sloping to steep Lindley soils formed in glacial till. They are commonly on dissected uplands near major streams and rivers. Lindley soils formed under timber vegetation, whereas the other minor soils formed under mixed vegetation of prairie and timber. The moderately well drained and somewhat poorly to poorly drained Nodaway and Vesser silt loams and some Colo and Ely silty clay loams are in drainageways. All formed in local alluvium. Nodaway and Vesser soils formed under mixed timber and prairie vegetation. Colo and Ely soils formed under prairie vegetation.

Most soils in this association have a high available water capacity. Caleb and Mystic soils, however, have a moderate available water capacity. Runoff is rapid and erosion is severe in many areas. The contact zone between the loess and the glacial till is seasonally wet and seepy. Many waterways dissect this association. Therefore, deep active gullies with trees and brush growing along the side slopes are more numerous than in other soil associations. Ponds for watering livestock help to stabilize many of the gullies.

Row crops are grown on the ridgetops and upper side slopes. A large part of this association is in meadow, permanent pasture, and woodland.

4. *Nodaway-Colo-Wabash association*

Nearly level to gently sloping, moderately well drained, poorly drained, very poorly drained bottom land soils that have a silt loam and silty clay loam surface layer and formed in alluvium

This soil association is on bottom land along the major rivers and creeks and their tributaries. It makes up about 7 percent of the county. About 49 percent is Nodaway soils, 22 percent Colo soils, 8 percent Wabash soils, and 21 percent minor soils.

Nodaway soils are moderately well drained. They are generally adjacent to the present stream channel but can occur at some distance from where the channel has been straightened. Some areas are channeled because of the cutting action of streams and rivers during flooding. The Nodaway soils typically are stratified very dark gray and grayish brown silt loam that extends to a depth of 80 inches.

Colo soils are poorly drained. They are adjacent to the Nodaway soils and near the uplands on smooth bottom land along major rivers, creeks, and their tributaries, and on alluvial fans. They have a thick black silty clay loam surface layer and a moderately slowly permeable, very dark gray silty clay loam subsoil.

Wabash soils are on flat areas of the bottom land, generally within areas of Colo soils, some distance from the stream channel. They typically have a black silty clay loam or silty clay surface layer about 40 inches thick. The subsoil is very dark gray silty clay.

Minor in this association are the well drained to moderately well drained Judson and Olmitz soils on alluvial fans; the somewhat poorly drained to very poorly drained Vesser and Humeston soils on second bottoms, low stream benches, or alluvial fans; and the moderately well drained Kennebec soils adjacent to rivers and streams.

The soils in this association have a high available water capacity. Colo soils generally can be tiled to improve drainage if outlets are available. Nodaway soils are subject to flooding, but usually no tile drainage is needed. Wabash soils usually stay wet longer in spring than Colo and Nodaway soils. Since it usually is not feasible to tile Wabash soils, surface drainage is used, depending on the outlets.

Row crops are suited to this soil association if timber is cleared and drainage and protection from flooding are adequate. Some areas in permanent pasture and meadow near stream channels or old oxbows are flooded frequently.

5. *Grundy-Haig association*

Nearly level to gently sloping, somewhat poorly drained and poorly drained upland soils that have a silty clay loam surface layer and a silty clay and silty clay loam subsoil and formed in loess

This association occupies the nearly level and gently sloping wide ridgetops and the lower convex slopes in the uplands. It also occurs as small areas in shallow depressions in the wide ridges.

This association makes up about 1 percent of the county. About 49 percent is Grundy soils, 45 percent Haig soils, and about 6 percent minor soils.

The gently sloping Grundy soils, on ridgetops and lower convex slopes, are somewhat poorly drained. The surface layer typically is black silty clay loam about 11 inches thick. The upper part of the subsoil is very dark gray to grayish brown silty clay loam, the next part, from 17 to 37 inches is silty clay, and the lower part, to a depth of about 4 feet, is heavy silty clay loam.

The nearly level to flat Haig soils, on upland divides, are poorly drained. The surface layer typically is black silty clay loam about 18 inches thick. The upper part of the subsoil is very dark gray silty clay loam. The next part, below 24 inches, is dark gray silty clay that grades to olive gray with depth. The lower part is olive gray silty clay loam.

Minor in this association are the Sperry and Clarinda soils. The very poorly drained Sperry soils are in the depressional areas of the nearly level divides. They have a lighter colored surface layer than the Grundy and Haig soils. The very poorly drained Clarinda soils are at the heads of drainageways adjacent to the Grundy and Haig soils.

The soils in this association have a high available water capacity. The Haig soils on the flats may pond seasonally. Surface drainage can alleviate this problem if an outlet is available.

The soils in this association are well suited to row crops. Corn and soybeans are the major crops. Much of the corn is fed to livestock. Soybeans is a cash grain crop. Only a small part of this association is in permanent pasture, generally the small acreage near farmsteads.

6. Shelby-Grundy association

Gently sloping to strongly sloping, well drained to somewhat poorly drained upland soils that have a clay loam and silty clay loam surface layer and formed in glacial till or loess

This soil association occupies the gently sloping lower ridgetops and divides, and the strongly sloping side slopes. Some areas of this association are in drainageways.

This association makes up about 8 percent of the county. About 19 percent is Shelby soils, 16 percent Grundy soils, (fig. 2) and 65 percent minor soils.

The Shelby soils, on convex side slopes and some narrow ridgetops, are moderately well drained or well drained. The surface layer typically is black and very dark grayish brown clay loam about 15 inches thick. The subsoil is dark brown, dark yellowish brown, and brown clay loam extending to a depth of about 38 inches.

The gently sloping Grundy soils, on side slopes and ridgetops that surround nearly level upland divides, are somewhat poorly drained. The surface layer typically is black silty clay loam about 11 inches thick. The upper part of the subsoil is very dark gray to grayish brown silty clay loam, the next part, from 17 to 47 inches, is silty clay, and the lower part, to a depth of about 4 feet, is heavy silty clay loam.

Minor in this association are the Clarinda, Lamoni, Adair, Lineville, Colo, and Ely soils. The very poorly drained Clarinda soils occupy the heads of drainageways, narrow bands on side slopes, and narrow convex ridgetops on uplands below the Grundy soils. The

***Figure 2.*—Typical landscape in Shelby-Grundy association. Shelby soils, in pasture, are on the side slopes. Grundy soils are on the narrow ridgetops.**

moderately well to somewhat poorly drained Adair soils are on convex ridgetops, commonly in bands at the shoulders of side slopes. The moderately and strongly sloping, somewhat poorly drained Lamoni soils occupy the heads of branching waterways downslope from the Grundy soils. The moderately well drained to somewhat poorly drained Lineville soils, on ridgetops, are downslope from the Grundy soils and upslope from the Shelby soils. The poorly drained to somewhat poorly drained Colo and Ely soils are in drainageways.

The soils in this association have high available water capacity. Runoff is rapid in many areas, and erosion is moderate to severe. The contact zone between the loess and the glacial till is seasonally wet and seepy. Interceptor tile can alleviate wetness. Terraces can reduce the hazard of erosion and thus improve crop production.

Row crops are grown on ridgetops and upper side slopes. The lower convex slopes are usually in meadow or permanent pasture.

7. *Gara-Pershing association*

Gently sloping to steep, well drained and moderately well drained upland soils that have a loam and silt loam surface layer and formed in glacial till or loess

This soil association is on the hilly, strongly dissected areas along major streams and tributaries. The main features are narrow convex ridgetops, long steep convex side slopes, and narrow upland valleys.

This association makes up about 14 percent of the county. About 35 percent is Gara soils, 28 percent Pershing soils, and 37 percent minor soils.

The strongly sloping to steep Gara soils are on side slopes. They are well drained or moderately well drained. They typically have a very dark gray loam surface layer about 7 inches thick. The subsurface layer is dark grayish brown loam about 5 inches thick. The subsoil is dark yellowish brown loam in the upper part. Below a depth of 17 inches, it is dark yellowish brown and yellowish brown clay loam. It extends to a depth of about 40 inches.

The gently sloping to strongly sloping Pershing soils are on convex slopes bordering nearly level interstream divides and on benches along major flood plains. They are somewhat poorly drained and moderately well drained. They typically have a very dark grayish brown silt loam surface layer about 7 inches thick. The subsurface layer is dark grayish brown silt loam about 3 inches thick. The upper part of the subsoil is brown silty clay loam, the next part is yellowish brown and grayish brown silty clay, and the lower part is mottled yellowish brown and grayish brown silty clay loam.

Minor in this association are the Armstrong, Keswick, Weller, Belinda, Lindley, Mystic, Caleb, Nodaway, and Vesser soils. The Armstrong and Keswick soils, on shoulders of side slopes and lower convex ridgetops in the uplands, are somewhat poorly drained or moderately well drained. The nearly level Belinda soils, on terraces near flood plains along major streams, are poorly drained. The Weller soils, on narrow ridgetops, upper side slopes, and benches along major streams, are moderately well drained. The Lindley soils, on convex upland side slopes near major streams and rivers, are moderately well drained. The Caleb and Mystic soils, on benches along major streams and tributaries, are moderately well drained or somewhat poorly drained. The Nodaway and Vesser soils in local alluvium in drainageways are moderately well drained or somewhat poorly drained to poorly drained.

Most soils in this association formed under mixed prairie and timber vegetation. Belinda, Weller, Keswick, and Lindley soils formed under timber. Available water capacity is high in Weller, Lindley, Nodaway, and Vesser soils; moderately high in Armstrong and Belinda soils; and moderate in the rest.

Row crops are grown on ridgetops, upper side slopes, and benches along major streams and rivers. A large part of this association is in meadow, permanent pasture, and woodland.

Descriptions of the Soils

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

An important part of the description of each soil series is the soil profile, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is more detailed and is for those who wish to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. The profile described in the series is representative of map units in that series. If the profile of a given map unit differs from the profile for the series, the differences are either stated in describing the map unit or are apparent in the name of the map unit.

Preceding the name of each map unit is a symbol. This symbol identifies the map unit on the detailed soil map. Listed at the end of each description of a map unit is the capability unit to which the map unit has been assigned.

The acreage and proportionate extent of each map unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey. Detailed information about the terminology and methods of soil mapping is in the Soil Survey Manual.

Adair Series

The Adair series consists of soils formed in highly weathered glacial till. These soils are on uplands. They are moderately sloping to moderately steep and somewhat poorly drained. They are on narrow convex ridges and upper side slopes. Slopes are 5 to 18 percent. The native vegetation was prairie grasses.

The surface layer is very dark gray, friable clay

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	421	0.2
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes	39,045	14.4
13B	Nodaway-Vesser silt loams, 2 to 5 percent slopes	3,325	1.2
23C	Arispe silty clay loam, 5 to 9 percent slopes	2,602	1.0
24C	Shelby clay loam, 5 to 9 percent slopes	395	0.1
24C2	Shelby clay loam, 5 to 9 percent slopes, moderately eroded	1.475	0.5
24D	Shelby clay loam, 9 to 14 percent slopes	2,850	1.0
24D2	Shelby clay loam, 9 to 14 percent slopes, moderately eroded	16,007	5.9
24D3	Shelby clay loam, 9 to 14 percent slopes, severely eroded	401	0.1
24E	Shelby clay loam, 14 to 18 percent slopes	2,078	0.8
24E2	Shelby clay loam, 14 to 18 percent slopes, moderately eroded	3,963	1.5
24F2	Shelby clay loam, 18 to 25 percent slopes, moderately eroded	251	0.1
51	Vesser silt loam, 0 to 2 percent slopes	973	0.4
65E	Lindley loam, 14 to 18 percent slopes	382	0.1
65F	Lindley loam, 18 to 25 percent slopes	372	0.1
69C	Clearfield silty clay loam, 5 to 9 percent slopes	6,707	2.5
76B	Ladoga silt loam, 2 to 5 percent slopes	652	0.2
76C	Ladoga silt loam, 5 to 9 percent slopes	3,570	1.3
76C2	Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	992	0.4
76D	Ladoga silt loam, 9 to 14 percent slopes	529	0.2
T76B	Ladoga silt loam, benches, 2 to 5 percent slopes	428	0.2
T76C	Ladoga silt loam, benches, 5 to 9 percent slopes	337	0.1
93D	Adair-Shelby clay loams, 9 to 14 percent slopes	2,525	0.9
93D2	Adair-Shelby clay loams, 9 to 14 percent slopes, moderately eroded	13,500	5.0
93E2	Adair-Shelby clay loams, 14 to 18 percent slopes, moderately eroded	549	0.2
94D2	Mystic-Caleb complex, 9 to 14 percent slopes, moderately eroded	1,688	0.6
122	Sperry silt loam, 0 to 2 percent slopes	189	0.1
T130	Belinda silt loam, benches, 0 to 2 percent slopes	325	0.1
131C	Pershing silt loam, 5 to 9 percent slopes	4,389	1.6
131C2	Pershing silt loam, 5 to 9 percent slopes, moderately eroded	3,000	1.1
131D	Pershing silt loam, 9 to 14 percent slopes	290	0.1
T131B	Pershing silt loam, benches, 2 to 5 percent slopes	684	0.3
T131C	Pershing silt loam, benches, 5 to 9 percent slopes	750	0.3
132C	Weller silt loam, 5 to 9 percent slopes	423	0.2
133	Colo silty clay loam, 0 to 2 percent slopes	3,125	1.1
133B	Colo silty clay loam, 2 to 5 percent slopes	1,175	0.4
175D	Dickinson fine sandy loam, 5 to 14 percent slopes	268	0.1
179D	Gara loam, 9 to 14 percent slopes	1,038	0.4
179D2	Gara loam, 9 to 14 percent slopes, moderately eroded	3,760	1.4
179E	Gara loam, 14 to 18 percent slopes	1,475	0.5
179E2	Gara loam, 14 to 18 percent slopes, moderately eroded	6,427	2.4
179F	Gara loam, 18 to 25 percent slopes	3,297	1.2
192C	Adair clay loam, 5 to 9 percent slopes	943	0.3
192C2	Adair clay loam, 5 to 9 percent slopes, moderately eroded	5,450	2.0
192D2	Adair clay loam, 9 to 14 percent slopes, moderately eroded	658	0.2
212	Kennebec silt loam, 0 to 2 percent slopes	1,130	0.4
220	Nodaway silt loam, 0 to 2 percent slopes	8,700	3.2
C220	Nodaway silt loam, 0 to 2 percent slopes, channeled	789	0.3
222C	Clarinda silty clay loam, 5 to 9 percent slopes	7,250	2.7
222C2	Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	8,879	3.3
222D	Clarinda silty clay loam, 9 to 14 percent slopes	1,275	0.5
222D2	Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	1,388	0.5
248	Wabash silty clay loam, 0 to 2 percent slopes	1,815	0.7
269	Humeston silty clay loam, 0 to 2 percent slopes	599	0.2
273B	Olmitz loam, 2 to 5 percent slopes	669	0.2
362	Haig silty clay loam, 0 to 2 percent slopes	915	0.3
364B	Grundy silty clay loam, 2 to 5 percent slopes	1,925	0.7
368	Macksburg silty clay loam, 0 to 2 percent slopes	7,960	2.9
368B	Macksburg silty clay loam, 2 to 5 percent slopes	3,350	1.2
369	Winterset silty clay loam, 0 to 2 percent slopes	4,540	1.7
370B	Sharpsburg silty clay loam, 2 to 5 percent slopes	20,054	7.4
370C	Sharpsburg silty clay loam, 5 to 9 percent slopes	7,050	2.6
370C2	Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	814	0.3
370D	Sharpsburg silty clay loam, 9 to 14 percent slopes	994	0.4
371C	Nira-Sharpsburg silty clay loams, 5 to 9 percent slopes	24,500	9.0
371C2	Nira-Sharpsburg silty clay loams, 5 to 9 percent slopes, moderately eroded	748	0.3
425C	Keswick loam, 5 to 9 percent slopes	325	0.1
451C2	Caleb loam, 5 to 9 percent slopes, moderately eroded	249	0.1
451D2	Caleb loam, 9 to 14 percent slopes, moderately eroded	1,407	0.5
451E2	Caleb loam, 14 to 18 percent slopes, moderately eroded	552	0.2

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

Map symbol	Soil name	Acres	Percent	Map symbol	Soil name	Acres	Percent
452C	Lineville silt loam, 5 to 9 percent slopes	226	0.1	822D	Lamoni silty clay loam, 9 to 14 percent slopes	495	0.2
592C2	Mystic silt loam, 5 to 9 percent slopes, moderately eroded	880	0.3	822D2	Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded	539	0.2
592D2	Mystic silt loam, 9 to 14 percent slopes, moderately eroded	423	0.2	993D2	Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded	6,860	2.5
792C	Armstrong loam, 5 to 9 percent slopes	1,250	0.5	993E2	Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded	248	0.1
792C2	Armstrong loam, 5 to 9 percent slopes, moderately eroded	3,725	1.4		Water, Quarries, and Borrow areas	1,200	0.4
792D2	Armstrong loam, 9 to 14 percent slopes, moderately eroded	1,215	0.4		Total	272,000	100.0
822C	Lamoni silty clay loam, 5 to 9 percent slopes	404	0.1				
822C2	Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded	2,975	1.1				

loam. It has fine granular structure and is about 16 inches thick. The subsoil is a mottled brown and dark reddish brown light clay that grades to a yellowish brown, firm clay loam.

These soils are slowly permeable and have a moderately high available water capacity. They have a deep root zone, but root growth is slow in the clayey, slowly permeable subsoil. The subsoil is very low in available phosphorus and very low to low in available potassium. Unless limed, the surface layer is medium acid.

Adair soils are suited to crops, but have severe limitations. They produce good hay and pasture. They are not too sloping for tillage but are limited by fertility and the clayey subsoil.

Representative profile of Adair clay loam, 5 to 9 percent slopes, 2,505 feet north and 165 feet west of the southeast corner of sec. 32, T. 71 N., R. 30 W. on a southeast facing slope of 6 percent:

Ap—0 to 6 inches; very dark gray (10YR 3/1) light clay loam; moderate fine subangular blocky structure parting to weak fine granular; friable; few large root channels and worm holes; medium acid; clear smooth boundary.

A12—6 to 11 inches; very dark gray (10YR 3/1) light clay loam that has few very dark grayish brown (10YR 3/2) peds; weak very fine subangular blocky structure parting to weak very fine granular; friable; few medium sand grains; few root channels and worm holes; medium acid; gradual smooth boundary.

A3—11 to 16 inches; very dark gray (10YR 3/1) medium clay loam with many peds of very dark brown (7.5YR 3/2); weak very fine subangular blocky structure; friable; few root channels and worm holes; medium acid; gradual smooth boundary.

IIB21t—16 to 26 inches; mottled brown (7.5YR 4/4) and dark reddish brown (5YR 3/4) light clay; few fine dark grayish brown (10YR 4/2) mottles; fine and medium subangular blocky structure; very firm; few very fine pores filled with clay; thin or medium continuous clay films; few brown (10YR 4/3) and very dark brown (10YR 3/2) coatings on peds; common fine pebbles in upper part of horizon; medium acid; gradual smooth boundary.

IIB22t—26 to 35 inches; dark yellowish brown (10YR 4/4) light clay; many fine distinct yellowish brown (10YR 5/6 and 5/8) mottles and few fine distinct dark reddish brown (5YR 3/4) mottles; moderate medium subangular blocky structure; very firm; thin or medium discontinuous clay films; few brown (10YR 4/3) coatings on peds; few fine pores; common fine pebbles; few fine dark bodies; slightly acid; gradual smooth boundary.

IIB31t—35 to 48 inches; dark yellowish brown (10YR 4/4) clay loam; many fine and medium distinct yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; very firm; few thin discontinuous brown (7.5YR 4/2) clay films; some dark stains in root channels; neutral; gradual smooth boundary.

IIB32t—48 to 60 inches; yellowish brown (10YR 5/6) light clay loam; many medium distinct light brownish gray (10YR 6/2) mottles; weak medium prismatic structure parting to weak medium angular blocky; firm; few thin discontinuous grayish brown (10YR 5/2) clay films on vertical cleavage faces; common fine dark bodies; neutral.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). It is dominantly clay loam, but the range includes silt loam. The A horizon ranges from medium acid to slightly acid.

The IIB2t horizon ranges from clay loam to clay and from strongly to slightly acid.

The moderately eroded units of Adair clay loam and Adair-Shelby clay loams are outside the defined range for the series because they lack a mollic epipedon. This difference, however, does not alter the use and behavior of the soils.

Adair soils are associated on the landscape with Sharpsburg, Grundy, and Shelby soils. They formed in parent material similar to that of Armstrong and Keswick soils. They have more clay in the B horizon than Sharpsburg, Grundy, and Shelby soils. They have a thicker A horizon than Armstrong and Keswick soils.

192C—Adair clay loam, 5 to 9 percent slopes. This moderately sloping soil is on side slopes and ridges. It occurs as long, narrow and irregularly shaped bands in the uplands. The profile is the one described as representative of the series.

Included with this soil in mapping are small areas of Shelby, Clarinda, and Lineville soils. Also included are small eroded areas, which are identified by spot symbols on the soil map.

This Adair soil is suited to cultivated row crops, but it is susceptible to erosion. Erosion control is needed if it is used for row crops. The organic-matter content is 2 to 4 percent. Capability unit IIIe–4.

192C2—Adair clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on side slopes above Shelby soils or extending ridges below soils formed in loess. It occurs as long, narrow and irregularly shaped areas. It has a profile similar to the one described as representative of the series, but the surface layer is thinner.

Included with this soil in mapping are small areas of Shelby, Clarinda, and Lineville soils. Also included are small eroded areas, which are identified by spot symbols on the soil map.

This Adair soil is suited to cultivated row crops, but it is susceptible to further erosion. If it is used for row crops, erosion control is needed to prevent further erosion and gully formation. The organic-matter content is 2 to 4 percent. Capability unit IIIe–4.

192D2—Adair clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on narrow side slopes or long ridges. It has a profile similar to the one described as representative of the series, but the surface layer is thinner.

Included with this soil in mapping are small areas of Shelby and Sharpsburg soils. Also included are severely eroded areas, which are identified by spot symbols on the soil map.

This Adair soil is better suited to hay and pasture than to row crops because it is susceptible to further erosion. Occasionally it can be row cropped. It is row cropped if it occurs in fields with better suited soils. Erosion control, such as seeding, terraces, and interceptor tile, is essential. The organic-matter content is 2 to 4 percent. Capability unit IVe–4.

93D—Adair-Shelby clay loams, 9 to 14 percent slopes. This strongly sloping map unit is on side slopes. It is 50 percent Adair soil and 40 percent Shelby soil. Areas are irregular in size and shape.

Included with this unit in mapping are small areas of Gara, Clarinda, and Lamoni soils. Gara soils are on the lower parts of slopes, and Clarinda and Lamoni soils are on the upper parts.

This map unit is generally better suited to pasture and hay than to cultivated crops. It is susceptible to erosion. Erosion control is needed. The organic-matter content is 2 to 4 percent. Capability unit IVe–4.

93D2—Adair-Shelby clay loams, 9 to 14 percent slopes, moderately eroded. This strongly sloping map unit is on side slopes. It is 50 percent Adair soil and 40 percent Shelby soil. It occurs in almost all parts of the county. Areas are irregular in size and shape. The clay loam surface layer is less than 7 inches thick.

Included with this unit in mapping are small areas of Gara, Clarinda, and Lamoni soils. Gara soils are on the lower parts of slopes, and Clarinda and Lamoni soils are on the upper parts.

This map unit is generally better suited to pasture and hay than to cultivated crops. It is susceptible to further erosion. Erosion control is needed. The organic-matter content is 2 to 4 percent. Capability unit IVe–4.

93E2—Adair-Shelby clay loams, 14 to 18 percent slopes, moderately eroded. This moderately steep map unit is on side slopes. It is 50 percent Adair soils and 40 percent Shelby soils. The clay loam surface layer is less than 7 inches thick. Included in mapping are small areas of Gara and Armstrong soils.

This map unit is generally better suited to hay and pasture than to cultivated crops. It is susceptible to erosion because of the moderately steep slopes. The organic-matter content is 2 to 4 percent. Capability unit VIe–2.

Arispe Series

The Arispe series consists of moderately well drained and somewhat poorly drained soils. These moderately sloping soils are on short side slopes. They formed in loess under native vegetation of prairie grasses. Slopes are 5 to 9 percent.

In a representative profile the surface layer is black, friable silty clay loam about 7 inches thick. The subsoil is silty clay loam that extends to a depth of 48 inches. The upper 6 inches is very dark gray and friable, the next 10 inches is dark grayish brown and firm, and the lower 25 inches is grayish brown and firm. The substratum is grayish brown, friable silty clay loam mottled with strong brown.

Arispe soils have moderately slow permeability and high available water capacity. The available subsoil phosphorus is very low to low, and available subsoil potassium is low to medium. Unless limed, these soils are slightly acid in the surface layer.

The Arispe soils are used primarily for row crops. The major limitation is erosion.

Representative profile of Arispe silty clay loam, 5 to 9 percent slopes, 360 feet east and 2,390 feet north of the southwest corner of sec. 31, T. 71 N., R. 28 W.

Ap—0 to 7 inches; black (10YR 2/1) light silty clay loam; dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate fine granular; friable; many roots; slightly acid; clear smooth boundary.

B1—7 to 13 inches; very dark gray (10YR 3/1) medium silty clay loam; very dark grayish brown (10YR 3/2) crushed; moderate and strong very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21t—13 to 18 inches; dark grayish brown (10YR 4/2) medium silty clay loam; many fine distinct yellowish brown (10YR 5/4) and olive brown (2.5Y 4/4) mottles; strong very fine subangular blocky structure; firm; thin discontinous clay films; few black (10YR 2/1) coatings on faces of peds; slightly acid; clear smooth boundary.

B22t—18 to 23 inches; dark grayish brown (2.5Y 4/2) heavy silty clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; strong fine and very fine subangular blocky structure; firm; continuous very dark (10YR 3/1) and dark gray (10YR 4/1) clay films; few dark bodies; slightly acid; clear smooth boundary.

B23t—23 to 29 inches; grayish brown (2.5Y 5/2) silty clay loam; common fine distinct strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to moderate fine and very fine subangular blocky; firm; discontinuous very dark gray (10YR 3/1) and gray (10YR 4/1) clay films; common dark bodies; slightly acid; gradual smooth boundary.

B31t—29 to 34 inches; grayish brown (2.5Y 5/2) silty clay loam; common fine reddish brown (5YR 4/4) and yellowish brown (10YR 5/6) mottles; moderate medium prismatic structure parting to moderate medium subangular blocky; firm; discontinuous dark gray (10YR 4/1) clay films on vertical faces of peds; few dark oxides; slightly acid; gradual smooth boundary.

B32t—34 to 40 inches; grayish brown (2.5Y 5/2) silty clay loam; common fine yellowish brown (10YR 5/6 and 5/8) mottles; moderate medium and fine prismatic structure; firm; discontinuous gray (10YR 5/1) clay films on vertical cleavage faces; few dark bodies; slightly acid; gradual smooth boundary.

B33t—40 to 48 inches; grayish brown (2.5Y 5/2) light silty clay loam; common fine and medium strong brown (7.5YR 5/6) mottles; massive with some vertical cleavage faces; friable; thin discontinuous clay films on vertical cleavage faces; few fine dark bodies; neutral; gradual smooth boundary.

C—48 to 60 inches; grayish brown (2.5Y 5/2) light silty clay loam; common fine and medium strong brown (7.5YR 5/6) mottles; massive; friable; few fine dark bodies; neutral.

The Ap horizon ranges from heavy silt loam to light silty clay loam. It is 6 to 10 inches thick.

Arispe soils are associated on the landscape with Grundy and Clarinda soils. They formed in parent material similar to that of Grundy soils. Arispe soils have a less clayey B horizon than Clarinda and Grundy soils.

23C—Arispe silty clay loam, 5 to 9 percent slopes. This moderately sloping soil is on side slopes in the southeastern part of the county. Individual areas vary in size and shape. Included with this soil in mapping are small areas of more eroded Arispe soils.

This Arispe soil is well suited to row crops, but it is susceptible to erosion. The organic-matter content is 2 to 4 percent. Capability unit IIIe–1.

Armstrong Series

The Armstrong series consists of upland soils formed in weathered glacial till. These soils are moderately well drained to somewhat poorly drained. They are on narrow convex ridges and upper side slopes. Slopes are 5 to 18 percent. The native vegetation was grass and trees.

The surface layer is very dark gray, friable loam. It has a fine granular structure and is about 6 inches thick. The subsurface layer is dark grayish brown, friable loam about 4 inches thick. It has medium platy structure parting to fine subangular blocky. The subsoil extends to a depth of 60 inches or more. It is dark yellowish brown and brown clay loam in the upper part; brown, strong brown, grayish brown, yellowish red, and light brownish gray light clay in the next part; and mottled strong brown, light brownish gray, and yellowish brown clay loam with light gray mottles in the lower part.

Armstrong soils have slow permeability and a moderately high available water capacity. The subsoil is very low in available phosphorus and potassium. Unless limed, the surface layer is generally slightly to medium acid.

Armstrong soils are suited to crops, but have severe limitations. They are highly susceptible to erosion where used for row crops. They produce good hay and pasture, but they are limited by fertility and the clayey subsoil.

Representative profile of Armstrong loam, 5 to 9 percent slopes, 330 feet east and 470 feet north of the southwest corner of sec. 7, T. 73 N., R. 28 W. on a narrow 7 percent ridge:

Ap—0 to 6 inches; very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) dry; mixing of brown (10YR 4/3); weak cloddy structure breaking to weak fine granular; friable; slightly acid; abrupt smooth boundary.

A2—6 to 10 inches; dark grayish brown (10YR 4/2) loam; about 10 percent very dark grayish brown (10YR 3/2); grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) dry; moderate medium platy structure breaking to moderate fine subangular blocky; friable; medium acid; clear smooth boundary.

B1—10 to 15 inches; dark yellowish brown (10 YR 4/4) light clay loam; few fine faint yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; friable; very dark gray (10YR 3/1) stains on some peds; strongly acid; clear smooth boundary.

B21t—15 to 18 inches; brown (7.5YR 4/4) medium clay loam; few fine distinct reddish brown (5YR 4/4) and yellowish red (5YR 4/6) mottles; moderate fine subangular blocky structure; firm; very dark gray (10YR 3/1) stains on some peds; few thin discontinuous clay films; few small pebbles; strongly acid; gradual smooth boundary.

IIB22t—18 to 24 inches; mottled brown (7.5YR 4/4), strong brown (7.5YR 5/6), grayish brown (10YR 5/2), and yellowish red (5YR 5/6) light clay; moderate and strong fine subangular blocky structure; firm; few dark bodies; few fine pebbles; thick continuous clay films on peds; very strongly acid; gradual smooth boundary.

IIB23t—24 to 31 inches; mottled strong brown (7.5YR 5/6) and light brownish gray (10YR 6/2) light clay; few fine brown (7.5YR 4/4) mottles; moderate fine subangular blocky structure; firm; few dark bodies; few fine pebbles; thick continuous clay films; strongly acid; gradual smooth boundary.

IIB24t—31 to 43 inches; mottled strong brown (7.5YR 5/6) and light brownish gray (10YR 6/2) heavy clay loam; moderate prismatic structure breaking to weak fine medium subangular blocky; very firm; few dark bodies; thin discontinuous clay films on peds; common pebbles; strongly acid; gradual smooth boundary.

IIB3t—43 to 60 inches; yellowish brown (10YR 5/6) clay loam; common fine and medium distinct light gray (10YR 6/1) mottles; weak medium prismatic structure breaking to weak medium subangular blocky; firm; clay flows in some channels; common fine dark bodies; few pebbles; medium acid.

The Ap horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2).

The A2 horizon is dark grayish brown (10YR 4/2), very dark grayish brown (10YR 3/2), or brown (10YR 5/3). It is 3 to 6 inches thick and is medium to slightly acid.

The IIB2t horizon is mottled brown (7.5YR 4/4), strong brown (7.5YR 5/6), grayish brown (10YR 5/2), and yellowish red (5YR 5/6). It ranges from heavy clay loam to light clay and from very strongly acid to medium acid.

Armstrong soils are associated on the landscape with Pershing and Gara soils. They formed in parent material similar to that of Keswick and Adair soils. They have a thicker A1 horizon than Keswick soils and a thinner A1 horizon than Adair soils. They have more sand than the loess-derived Pershing soils and a more clayey B horizon than Gara soils.

792C—Armstrong loam, 5 to 9 percent slopes. This moderately sloping soil is on narrow ridges and upper side slopes. It occurs as long, narrow, and irregularly shaped bands in the uplands. The profile is the one described as representative of the series.

Included with this soil in mapping are small areas of Gara and Keswick soils. Some large areas of less clayey glacial till soils are identified by spot symbols on the soil map.

This soil is moderately well suited to row crops, but it is susceptible to erosion. Most areas are in timber pasture. Some are used for pasture and hay. A small acreage is in crops. The organic-matter content is 2 to 4 percent. Capability unit IIIe-4.

792C2—Armstrong loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on narrow ridges and upper side slopes. It occurs as long, narrow, and irregularly shaped areas. It has a profile similar to the one described as representative of the series, but the surface layer is thinner.

Included with this soil in mapping are small areas of Gara and Keswick soils. Some large areas of less clayey glacial till soils are identified by spot symbols on the soil map.

This soil is moderately well suited to row crops, but it is susceptible to erosion. Most areas have been cleared. Organic-matter content is less than one percent. Capability unit IIIe-4.

792D2—Armstrong loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on side slopes. It occurs as long, narrow, and irregularly shaped areas. It has a profile similar to the one described as representative of the series, but the surface layer is thinner. Included with this soil in mapping are small areas of Gara and Armstrong soils that are either less eroded or more severely eroded.

This soil is not well suited to row crops but is moderately well suited to pasture. It is susceptible to erosion. The organic-matter content is less than 1 percent. Capability unit IVe-4.

Belinda Series

The Belinda series consists of poorly drained soils. These nearly level soils are on high and medium high benches. They formed in loess under a native vegetation of prairie grass and trees. Slopes are 0 to 2 percent.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is grayish brown and light grayish brown silt loam about 11 inches thick. The subsoil, to a depth of 80 inches, is dark gray silty clay in the upper part, grayish brown and light brownish gray silty clay in the next part, and mottled gray and yellowish brown silty clay loam in the lower part.

Belinda soils have very slow permeability and a moderately high available water capacity. The subsoil is low in available phosphorus and very low in available potassium. Unless limed, the surface layer is generally medium acid.

Belinda soils are used primarily for cultivated crops and hay. The major hazard for crops is wetness.

Representative profile of Belinda silt loam, benches, 0 to 2 percent slopes, 1,850 feet west and 1,150 feet north of southeast corner of sec. 26, T. 71 N., R. 28 W. in a bluegrass pasture:

Ap—0 to 7 inches; very dark gray (10YR 3/1) silt loam; grayish brown (10YR 5/2) dry; weak very thin platy structure parting to weak very fine granular; friable; medium acid; abrupt smooth boundary.

A21—7 to 10 inches; grayish brown (10YR 5/2) silt loam; light gray (10YR 7/3) dry; moderate medium platy structure; few fine faint yellowish brown (10YR 5/4) mottles; friable; medium acid; clear smooth boundary.

A22—10 to 14 inches; grayish brown (10YR 5/2) silt loam; light gray (10YR 7/2) dry; few fine faint yellowish brown (10YR 5/4) mottles; weak very thin platy structure; friable; medium acid; clear smooth boundary.

A23—14 to 18 inches; grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) silt loam; light gray (10YR 7/2) dry; weak medium platy structure parting to weak fine subangular blocky; friable; medium acid; abrupt smooth boundary.

AB—18 to 20 inches; dark grayish brown (10YR 4/2) silty clay loam; common medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; moderate fine subangular blocky structure; firm; nearly continuous grayish brown (10YR 5/2) coatings on peds; strongly acid; clear smooth boundary.

B21t—20 to 27 inches; dark gray (10YR 4/1) silty clay; common medium distinct yellowish brown (10YR 5/6 and 5/8) and few fine distinct brown (7.5YR 4/4) mottles; strong fine and very fine subangular blocky structure; firm; thick nearly continuous very dark gray (10YR 3/1) clay films on peds; few fine dark bodies; strongly acid; gradual smooth boundary.

B22t—27 to 35 inches; grayish brown (10YR 5/2) silty clay; common medium distinct yellowish brown (10YR 5/6 and 5/8) and few fine distinct brown (7.5YR 4/4) mottles; strong fine subangular blocky structure; very firm; thin discontinuous dark grayish brown (10YR 4/2) clay films on peds; few fine dark bodies; strongly acid; gradual smooth boundary.

B23t—35 to 43 inches; light brownish gray (10YR 6/2) silty clay; common medium distinct yellowish brown (10YR 5/6 and 5/8) and few fine distinct brown (7.5YR 4/4) mottles; weak fine prismatic structure parting to moderate fine subangular blocky; firm; thin discontinuous grayish brown (2.5Y 5/2) clay films on peds; few fine dark bodies; medium acid; gradual smooth boundary.

B31t—43 to 51 inches; mottled gray (5Y 5/1) and yellowish brown (10YR 5/4, 5/6, and 5/8) silty clay loam; common medium brown (7.5YR 4/4) mottles; weak medium prismatic structure; dark gray (10YR 4/1) thin discontinuous clay films; medium acid; gradual smooth boundary.

B32t—51 to 80 inches; mottled gray (5Y 5/1) and yellowish brown (10YR 5/4, 5/6, and 5/8) silty clay loam; few fine brown (7.5YR 4/4) mottles; weak medium prismatic structure; firm; few thin dark gray (10YR 4/1) discontinuous clay films; medium acid.

The Ap horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2).

The A2 horizon ranges from dark grayish brown (10YR 4/2) to light brownish gray (2.5Y 6/2). It is 6 to 14 inches thick.

The B2t horizon ranges from very dark gray (10YR 3/1) to grayish brown (2.5Y 5/2) and light brownish gray (10YR 6/2). It is 18 to 25 inches thick and ranges from strongly acid to slightly acid.

The Belinda soils are associated on the landscape with Weller soils and formed in similar parent materials. They have a thicker A2 horizon than those soils.

T130—Belinda silt loam, benches, 0 to 2 percent slopes. This nearly level soil is on low, loess-covered benches near the major streams. It is underlain by loamy or sandy alluvial sediments at a depth of 8 to 10 feet. Areas range from 4 to 40 acres in size and are irregular in shape. Included with this soil in mapping are small areas of Weller soils.

This Belinda soil is suited to row crops because it is level. It is susceptible to problems caused by wetness and poor drainage. Shallow surface ditches remove excess water and improve drainage. The high clay content of the subsoil limits effective use of tile lines. The organic-matter content is 1 to 4 percent. The potential is low for landfill and sewage lagoon sites because of the danger of ground water pollution. Capability unit IIIw-2.

Caleb Series

The Caleb series consists of moderately well drained soils. These moderately sloping to moderately steep soils are on high upland benches in small areas along the major streams in the county. They formed in water-sorted glacial sediments deposited as alluvium during an earlier geologic period. The native vegetation was grasses and trees. Slopes are 5 to 18 percent.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is brown loam about 2 inches thick. The subsoil extends to a depth of 72 inches. It is brown, firm loam or light clay loam in the upper part; brown and grayish brown firm clay loam in the next part; and brown and yellowish brown friable sandy loam and sandy clay loam in the lower part.

Caleb soils have moderately slow to slow permeability and have a moderate available water capacity.

The subsoil is very low in available phosphorus and is very low in available potassium. The surface layer is medium acid, and the subsoil is strongly acid.

The Caleb soils are used primarily for crops and pasture. The major limitations are erosion and rapid runoff.

Representative profile of Caleb loam, 9 to 14 percent slopes, moderately eroded, 610 feet north and 1,480 feet east of southwest corner of sec. 3, T. 71 N., R. 29 W.

Ap—0 to 6 inches; very dark gray (10YR 3/1) loam; grayish brown (10YR 5/2) dry; weak fine granular structure; friable; medium acid; abrupt smooth boundary.

A2—6 to 8 inches; brown (10YR 4/3) loam; weak coarse platy structure parting to moderate fine subangular blocky; friable; discontinuous light gray (10YR 7/2) dry silt and fine sand coatings on faces of peds; very strongly acid; clear smooth boundary.

B1—8 to 14 inches; brown (10YR 4/3) loam; strong fine and medium subangular blocky structure; firm; nearly continuous light gray (10YR 7/2) dry silt and fine sand coatings on faces of peds; strongly acid; clear smooth boundary.

B21t—14 to 20 inches; brown (10YR 4/3) clay loam; few fine faint yellowish brown (10YR 5/6) mottles; strong medium subangular blocky structure; firm; continuous light gray (10YR 7/2) dry silt and fine sand coatings on faces of peds; few clay films on faces of peds; very strongly acid; clear smooth boundary.

B22t—20 to 32 inches; brown (10YR 4/3) clay loam; few fine faint yellowish brown (10YR 5/6 and 5/8) mottles; strong medium prismatic structure parting to strong fine angular and subangular blocky; firm; thick discontinuous dark brown (7.5YR 3/2) clay films on ped faces; roots confined mainly along faces of peds; medium acid; gradual smooth boundary.

B23t—32 to 41 inches; mottled grayish brown (10YR 5/2) and brown (10YR 4/3) loam; strong medium prismatic structure parting to moderate medium subangular blocky; firm; thick patchy dark brown (7.5YR 3/2) clay films in upper part and few patchy clay films on ped faces and in root channels; medium acid; gradual smooth boundary.

B31t—41 to 47 inches; yellowish brown (10YR 5/4) light sandy clay loam; few fine faint yellowish brown (10YR 5/6 and 5/8) and pale brown (10YR 6/3) mottles; weak coarse prismatic structure; friable; thin clay films on horizontal ped faces; slightly acid; gradual smooth boundary.

B32—47 to 72 inches; brown (10YR 5/3) sandy loam; common fine faint yellowish brown (10YR 5/6 and 5/8) and light brownish gray (10YR 6/2) mottles; weak coarse prismatic structure; friable; few thin discontinuous grayish brown (10YR 5/2) clay films on faces of prisms and in old channels; slightly acid; a 2-inch strata of coarse sand is at a depth of 57 inches.

The Ap horizon ranges from very dark gray (10 YR 3/1) to very dark grayish brown (10YR 3/2). It is dominantly loam but includes silt loam.

The A2 horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3). It is silt loam to light clay loam.

The B2t horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/6). It ranges from clay loam to sandy clay loam in the upper part to coarser materials below a depth of 3 feet.

Caleb soils are associated on the landscape with Mystic and Gara soils. They have more sand in the lower B horizon than Gara soils and have less clay in the B horizon than Mystic soils.

451C2—Caleb loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on side slopes of high benches near major streams and tributaries. Areas are irregular in shape and size.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner.

Included with this soil in mapping are small areas of Gara, Armstrong, and Mystic soils. Also included are small areas of sand and small severely eroded areas, which are identified by spot symbols on the soil map.

This Caleb soil is suited to row crops if erosion is controlled and fertility maintained. It is susceptible to erosion. Small gullies develop easily. The organic-matter content is less than 1 percent. Capability unit IIIe-5.

451D2—Caleb loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on side slopes of high benches near major streams and tributaries and on short side slopes near stream bottoms. Areas are irregular in size and shape. Most areas are long and narrow.

This soil has a profile similar to the one described for the series, but the surface layer is very dark grayish brown loam 3 to 6 inches thick. Erosion has removed part of the original surface layer, and plowing has mixed what is left of this layer with the material from the subsoil. The present plow layer is gray or grayish brown when dry.

Included with this soil in mapping are small areas of adjacent soils and some areas that are more sandy than is typical. These spots are identified by spot symbols on the soil map if they are significant in management.

This soil is suited to row crops, but runoff is rapid and the loamy surface erodes readily if vegetation is sparse. It has no limitations for pasture, but small gullies develop in overgrazed spots. Individual areas are managed with other units. If erosion is controlled, this soil can be row cropped occasionally. The organic-matter content is less than 1 percent. Capability unit IVe-3.

451E2—Caleb loam, 14 to 18 percent slopes, moderately eroded. This moderately steep soil is on side slopes of high benches near major streams and tributaries. Areas are irregular in size and shape. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown.

Included with this soil in mapping are small areas of Gara, Armstrong, and Mystic soils; a few areas of less sloping soils; and small areas of soils that are either more eroded or less eroded. Also included, if significant in management, are spots of sand which are identified by spot symbols on the soil map. Some areas of severely eroded soils are also indicated by spot symbols on the soil map.

This Caleb soil is better suited to hay and pasture than to cultivated crops. It is susceptible to erosion. There is moderate limitation for pasture. Erosion control is needed. The organic-matter content is less than 1 percent. Capability unit VIe–1.

Clarinda Series

The Clarinda series consists of very poorly drained soils. These moderately sloping to strongly sloping soils are on short side slopes or around heads of drainageways. They formed in highly weathered glacial till under a native vegetation of water tolerant prairie grasses. Slopes are 5 to 14 percent.

In a representative profile the surface layer is very dark gray, friable silty clay loam and silty clay about 14 inches thick. The subsoil extends to a depth of 65 inches or more. It is dark gray, firm silty clay in the upper part and gray, very firm silty clay in the middle and lower part. This very sticky, gray clayey material is commonly known as "gumbotil."

Clarinda soils have very slow permeability and a high available water capacity. The subsoil is low in available phosphorus and low to medium in available potassium. The surface layer is medium acid, and the subsoil is strongly acid.

Clarinda soils are used primarily for hay and pasture. Some areas are cultivated with more suitable adjacent soils. The major limitation is wetness caused by seepiness at the contact of the Clarinda soils and the soils upslope. The soils are also subject to erosion.

Representative profile of Clarinda silty clay loam, 9 to 14 percent slopes, 2,070 feet north and 150 feet west of southeast corner of sec. 13, T. 72 N., R. 31 W. on a northeast facing slope of 10 percent:

Ap—0 to 7 inches; very dark gray (10YR 3/1) heavy silty clay loam; fine granular and very fine subangular blocky structure; friable; strongly acid; clear smooth boundary.

A3—7 to 14 inches; very dark gray (10YR 3/1) silty clay; moderate fine subangular blocky structure; friable; medium acid; clear smooth boundary.

IIB1t—14 to 20 inches; dark gray (10YR 4/1) silty clay; few fine distinct brown (7.5 YR 4/4) mottles; moderate fine subangular blocky structure; firm; common thick discontinuous very dark gray (10 YR 3/1) clay films; strongly acid; gradual smooth boundary.

IIB21t—20 to 33 inches; gray (5Y 5/1) silty clay; few fine distinct brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; very firm; thick continuous gray clay films on peds; common fine white sand grains; medium acid; gradual smooth boundary.

IIB22t—33 to 48 inches; gray (5Y 5/1) silty clay; few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure parting to coarse subangular blocky; very firm; thick continuous gray clay films; few white sand grains; medium acid; gradual smooth boundary.

IIB23t—48 to 65 inches; gray (5Y 5/1) silty clay; few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure parting to coarse subangular blocky; very firm; thick continuous gray clay films; some dark organic films on peds and in channels and crevices; few fine white sand grains; medium acid.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). It is dominantly silty clay loam, but the range includes silt loam. The A horizon ranges from strongly acid to medium acid.

The IIB horizon ranges from silty clay to clay. It is slightly to strongly acid. The moderately eroded units of Clarinda are outside the range defined for the Clarinda series because they lack a mollic epipedon. This difference, however, does not alter use and behavior.

Clarinda soils are associated on the landscape with Clearfield and Lamoni soils. They have a thicker gray, clayey B horizon than Lamoni and Clearfield soils.

222C—Clarinda silty clay loam, 5 to 9 percent slopes. This moderately sloping soil is on shoulders of uplands and in bands around the heads of drainageways. It occurs as long, irregularly shaped areas. Some areas are large.

Included with this soil in mapping are small areas of Clearfield and Lamoni soils. Also included are some more severely eroded areas.

This Clarinda soil is better suited to hay and pasture than to cultivated crops. It is susceptible to wetness and erosion. Erosion control is needed in cultivated areas. The organic-matter content is 2 to 4 percent. Capability unit IVw–1.

222C2—Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on shoulders and in heads of drainageways in the uplands. It occurs as long, narrow, and irregularly shaped areas. It has a profile similar to the one described as representative of the series, but the surface layer is thinner, about 6 inches thick.

Included with this soil in mapping are small areas of Clearfield and Nira soils. Also included are less clayey soils that are identified by spot symbols on the soil map if the areas are large enough. Because the surface layer has been mixed with the clay subsoil in many places by plowing, it is more clayey than the one described for the series.

This Clarinda soil is better suited to hay and pasture than to cultivated crops. It is susceptible to wetness and erosion. Erosion control is needed in cultivated areas. The organic-matter content is 2 to 4 percent. Capability unit IVw-1.

222D—Clarinda silty clay loam, 9 to 14 percent slopes. This strongly sloping upland soil is in narrow bands on the shoulders of side slopes and extends around the heads of drainageways. Areas range from long and narrow to short and wide, covering the entire slope. Areas are generally small. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are some small areas of Lamoni and Adair soils that are identified by spot symbols on the soil map. Generally these areas are dominantly Lamoni soil. Also included are some eroded areas, which are also identified by spot symbols on the soil map.

This Clarinda soil is better suited to hay and pasture than to row crops. It is susceptible to erosion. Runoff is excessive because slopes are strong and the subsoil is very slowly permeable. Erosion control practices and interceptor tile are needed upslope. The organic-matter content is 2 to 4 percent. Capability unit IVe-4.

222D2—Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is in narrow bands at the heads of drainageways and extends to the shoulders of the side slopes. Areas vary in size and shape but are generally small. This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner, about 6 inches thick.

Included with this soil in mapping are small areas of Lamoni and Adair soils. Generally these areas are dominantly Lamoni soil. Also included are small eroded areas, which are identified by spot symbols on the soil map.

This Clarinda soil is better suited to hay and pasture than to cultivated crops. It is susceptible to further erosion and is hard to manage because of the clayey subsoil and the strong slopes. Erosion control and interceptor tile are needed upslope to prevent seepage and erosion. The organic-matter content is 2 to 4 percent. Capability unit IVe-4.

Clearfield Series

The Clearfield series consists of poorly drained to somewhat poorly drained soils. These moderately sloping soils are on side slopes and coves on uplands. They formed in loess 3 to 6 feet thick over clayey glacial till, under native vegetation of prairie grasses tolerant to wetness. Slopes are 5 to 9 percent.

In a representative profile the surface layer is black and very dark gray, friable silty clay loam about 17 inches thick. The subsoil extends to a depth of 48 inches. It is dark gray, firm silty clay loam in the upper part; olive gray, firm silty clay loam in the next part; and light brownish gray to light gray, friable silty clay loam in the lower part. The substratum is dark gray to black, firm heavy silty clay loam that grades to silty clay.

Clearfield soils have moderately slow permeability and a high available water capacity. The subsoil is low in available phosphorus and potassium. Unless limed, the surface layer is generally slightly acid.

The Clearfield soils are used primarily for cultivated crops. The major limitation is wetness caused by drainage water, from areas of more permeable loess, which moves laterally over the compact, very slowly permeable underlying clay layer.

Representative profile of Clearfield silty clay loam, 5 to 9 percent slopes, 1,440 feet south and 1,467 feet east of northwest corner of sec. 21, T. 72 N., R. 30 W. on a 6 percent west-facing slope:

Ap—0 to 7 inches; black (10YR 2/1) medium silty clay loam; cloddy structure parting to weak fine granular; friable; common roots; slightly acid; abrupt smooth boundary.

A12—7 to 13 inches; black (10YR 2/1) light silty clay loam; moderate fine and very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

A3—13 to 17 inches; very dark gray (10YR 3/1) heavy silty clay loam; few fine faint yellowish brown (10YR 5/4) mottles; moderate very fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B21tg—17 to 25 inches; dark gray (10YR 4/1) medium silty clay loam; dark grayish brown (2.5Y 4/2) kneaded; many fine distinct reddish brown (2.5YR 4/4) mottles; weak medium subangular blocky structure parting to fine subangular blocky; firm; black (10YR 2/1) coatings in root channels and pores; thin discontinuous very dark gray clay films; few dark bodies; slightly acid; gradual smooth boundary.

B22tg—25 to 31 inches; olive gray (5Y 5/2) medium silty clay loam; common fine distinct dark gray (10YR 4/1) mottles, few fine distinct brown (7.5YR 4/4) mottles, and few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; moderate medium subangular blocky structure; firm; thin discontinuous clay films; few dark bodies; medium acid; gradual smooth boundary.

B23tg—31 to 39 inches; light brownish gray (5Y 5/1) light silty clay loam; many medium distinct strong brown (7.5YR 5/6 and 5/8) mottles, common medium distinct yellowish brown (10YR 5/6 and 5/8) mottles, and few medium distinct gray (10YR 5/1) mottles; weak medium prismatic structure parting to moderate medium subangular blocky; friable; thin discontinuous dark gray clay films on faces of prisms; slightly acid; clear smooth boundary.

B3—39 to 48 inches; light gray (5Y 6/1) light silty clay loam; many medium distinct yellowish brown (10YR 5/6 and 5/8) mottles and common medium distinct gray (10YR 5/1) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; a concentrated area of dark bodies in the upper 4 inches; slightly acid; abrupt smooth boundary.

IIA1b—48 to 54 inches; dark gray (N 4/0) medium silty clay loam; many fine prominent brown (7.5YR 4/4) and yellowish red (5YR 4/8) mottles; massive; firm; strata less than 2 inches thick of light gray (10YR 6/1) light silty clay loam with few fine brownish yellow (10YR 6/6) mottles; medium acid; abrupt smooth boundary.

IIIA1b—54 to 64 inches; black (10YR 2/1) heavy silty clay loam; massive; firm; few vertical cleavage faces; slightly acid; gradual smooth boundary.

IIIA2b—64 to 71 inches; dark gray (10YR 4/1) silty clay; few fine faint dark grayish brown (10YR 4/2) mottles; massive; firm; medium acid.

The A horizon ranges from black (N 2/0) to very dark gray (10YR 3/1). It is 15 to 20 inches thick.

The B2t horizon ranges from dark gray (10YR 4/1) to light brownish gray (2.5Y 6/2) and from strongly acid to slightly acid.

The IIAb horizon ranges from black (N 2/0) to dark gray (10YR 4/1) and from neutral to medium acid.

Clearfield soils are associated on the landscape with the Clarinda and Sharpsburg soils. They formed in parent material similar to that of Nira soils. They have less clay in the B horizon than Clarinda soils. They have chroma mottles higher up in the B horizon than Nira and Sharpsburg soils. The lower part of the solum formed in a gray paleosol instead of the gray loess typical of Nira soils.

69C—Clearfield silty clay loam, 5 to 9 percent slopes. This moderately sloping soil is on side slopes of the uplands. It generally occurs as broad areas near the heads of waterways. Areas tend to be long and narrow on the shoulders of side slopes.

Included with this soil in mapping are small areas of better drained soils and small areas of the very slowly permeable Clarinda soils. Significant spots of the gray clay Clarinda soils are identified by spot symbols on the soil map.

This Clearfield soil is suited to row crops, but in many undrained areas it is in pasture. It is seepy and susceptible to wetness. Runoff down the moderate slopes makes the soil subject to erosion. The organic-matter content is 4 to 6 percent. Capability unit IIIw-1.

Colo Series

The Colo series consists of poorly drained soils. These nearly level to gently sloping soils are on foot slopes and bottom lands. They formed in alluvium under native vegetation of water-tolerant prairie grasses. Slopes are 0 to 5 percent.

In a representative profile the surface layer is black silty clay loam about 41 inches thick. The substratum is very dark gray silty clay loam mottled with brown and yellowish brown.

These soils have moderately slow permeability and a high available water capacity. The subsoil is medium in available phosphorus and potassium. Unless limed, the surface layer is generally slightly acid.

Colo soils are used primarily for cultivated crops. The major limitations for crops are wetness and flooding of the bottom land.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, 210 feet east and 90 feet south of northwest corner of sec. 2, T. 73 N., R. 29 W. in a cornfield on the bottom land of the Thompson branch of the Grand River:

Ap—0 to 7 inches; black (10YR 2/1) light silty clay loam; weak medium subangular blocky structure parting to moderate fine granular; friable; slightly acid; abrupt smooth boundary.

A12—7 to 15 inches; black (10YR 2/1) light silty clay loam; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A13—15 to 22 inches; black (10YR 2/1) silty clay loam; moderate fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A14—22 to 31 inches; black (10YR 2/1) silty clay loam; moderate fine subangular blocky structure; firm; few fine and very fine dark bodies; slightly acid; diffuse smooth boundary.

AC—31 to 41 inches; black (10YR 2/1) silty clay loam; weak coarse prismatic structure parting to moderate medium blocky; firm; few fine and very fine dark bodies; slightly acid; diffuse smooth boundary.

C1—41 to 49 inches; very dark gray (10YR 3/1) silty clay loam; weak coarse and medium prismatic structure parting to weak coarse blocky; firm; common fine distinct brown (7.5YR 4/4) mottles; few fine and very fine dark bodies; slightly acid; diffuse smooth boundary.

C2—49 to 62 inches; very dark gray (10YR 3/1) silty clay loam; massive; firm; common fine distinct brown (7.5YR 4/4) mottles and few fine distinct yellowish brown (10YR 5/4) mottles; slightly acid.

The A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) and from neutral to medium acid.

The C horizon ranges from very dark gray (10YR 3/1) to dark gray (10YR 4/1) and from neutral to medium acid.

Colo soils are associated on the landscape with Wabash, Kennebec, and Nodaway soils. Colo soils are less clayey than Wabash soils but more clayey than Nodaway and Kennebec soils.

133—Colo silty clay loam, 0 to 2 percent slopes. This nearly level soil is on bottom land in the stream valleys. Areas range widely in size. Some are as large as 80 acres or more. The profile is the one described as representative of the series. Included in mapping are small areas of Wabash and Kennebec soils.

This soil is well suited to row crops, but it is susceptible to flooding and wetness. The organic-matter content is 4 to 6 percent. Capability unit IIw-1.

133B—Colo silty clay loam, 2 to 5 percent slopes.

This gently sloping soil is on level to slightly concave foot slopes of the uplands. Areas are generally not large. Included in mapping are small areas of Ely and Olmitz soils.

This soil is well suited to row crops. It is susceptible to wetness because it receives runoff and seepage from adjacent uplands. The organic-matter content is 4 to 6 percent. Capability unit IIw–4.

11B—Colo-Ely silty clay loams, 2 to 5 percent slopes. This gently sloping map unit is along narrow drainageways in the uplands. It is 50 percent Colo soils and 35 percent Ely soils. It occurs as long and narrow areas. Along the narrow drainageways, Colo soils are adjacent to the small streams, and Ely soils are near the base of the uplands. Some gullies have formed. The profile of the Ely soil is the one described as representative of the series.

This map unit is well suited to row crops, but it is susceptible to flooding and wetness. Most of the acreage is managed with adjacent steeper soils. The organic-matter content is 4 to 6 percent. Capability unit IIw–4.

Dickinson Series

The Dickinson series consists of well drained soils. These moderately sloping and strongly sloping soils are on side slopes in the uplands. Dickinson soils formed in eolian sands under native vegetation of grasses or widely spaced trees. Slopes are 5 to 14 percent.

In a representative profile the surface layer is black to very dark grayish brown and dark brown fine sandy loam about 23 inches thick. The subsoil, which extends to a depth of 34 inches, is dark yellowish brown medium sandy loam. The substratum is yellowish brown medium loamy sand.

Dickinson soils have rapid permeability and a low to moderate available water capacity. The subsoil is very low in available phosphorus and available potassium. These soils are neutral to slightly acid.

The Dickinson soils are used primarily for cultivated crops and pasture or woodland. Erosion is the major limitation for crops or pasture.

Representative profile of Dickinson fine sandy loam, 5 to 14 percent slopes, 1,470 feet east and 435 feet south of northwest corner of sec. 15, T. 72 N., R. 31 W. on a north-facing slope of 10 percent:

A1—0 to 9 inches; black (10YR 2/1) fine sandy loam; very weak medium and fine subangular blocky structure; very friable; neutral; clear smooth boundary.

A12—9 to 15 inches; very dark grayish brown (10YR 3/2) fine sandy loam; very weak medium and fine subangular blocky structure; very friable; slightly acid; gradual smooth boundary.

A3—15 to 23 inches; very dark grayish brown (10YR 3/2) fine sandy loam; some dark yellowish brown (10YR 4/4) fine peds in lower part; weak medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B—23 to 34 inches; dark yellowish brown (10YR 4/4) sandy loam; single grained; friable; slightly acid; gradual smooth boundary.

C—34 to 60 inches; yellowish brown (10YR 5/6) loamy sand; single grained; friable; a 3-inch pale brown (10YR 6/3) silt stratum at a depth of 48 inches contains few fine distinct brown (7.5YR 4/4) mottles and is massive; slightly acid.

Texture of the A horizon ranges from fine sandy loam to loam.

The B horizon ranges from dark grayish brown (10YR 3/2) to yellowish brown (10YR 5/4). Texture ranges from sandy loam to loamy sand.

The C horizon ranges from brown (10YR 4/3) to yellowish brown (10YR 5/6). Texture ranges from loamy sand to sand.

Dickinson soils are associated on the landscape with Sharpsburg and Ladoga soils. They have more sand throughout the solum than those soils.

175D—Dickinson fine sandy loam, 5 to 14 percent slopes. This moderately sloping and strongly sloping soil is on side slopes and points of ridges of the uplands. It occurs as small and irregularly shaped areas that are generally associated with larger drainageways. Included in mapping are small areas of Sharpsburg, Ladoga, or Shelby soils.

This Dickinson soil is better suited to pasture than to crops. It is susceptible to erosion. Because it is well drained and has rapid permeability, the soil tends to be droughty and may not support crops in dry times. The organic-matter content is 1 to 2 percent. Capability unit IVe–6.

Ely Series

The Ely series consists of somewhat poorly drained soils. These gently sloping soils are on foot slopes. They formed in local alluvium under native vegetation of prairie grasses. Slopes are 2 to 5 percent.

In a representative profile the surface layer is very dark brown, very dark gray, and black silty clay loam about 24 inches thick. The subsoil is very dark gray, dark grayish brown, grayish brown, and brown silty clay loam with yellowish brown mottles. The substratum is mixed gray and brown silty clay loam mottled with strong brown.

The Ely soils have moderate permeability and a high water capacity. The subsoil is very low in available phosphorus and available potassium. Unless limed, the surface layer is generally slightly acid.

The Ely soils are used primarily for cultivated crops. The major hazard for crops is erosion and runoff from adjacent uplands.

Representative profile of Ely silty clay loam in an area of Colo-Ely silty clay loams, 2 to 5 percent slopes, about 570 feet north, 950 feet west of the southeast corner of sec. 36, T. 71 N., R. 29 W. on a 3 percent foot slope:

Ap—0 to 8 inches; very dark brown (10YR 2/2) light silty clay loam; dark grayish brown (10YR 4/2) dry; moderate fine granular and weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A1—8 to 15 inches; black (10YR 2/1) light silty clay loam; crushes to very dark brown

(10YR 2/2); moderate fine granular structure; friable; slightly acid; clear smooth boundary.

A3—15 to 24 inches; very dark gray (10YR 3/1) light silty clay loam; crushes to very dark grayish brown (10YR 3/2); weak fine subangular blocky structure parting to moderate fine granular; friable; medium acid; clear smooth boundary.

B1—24 to 32 inches; very dark gray (10YR 3/1) light silty clay loam; crushed to very dark grayish brown (10YR 3/2); few fine faint dark grayish brown (10YR 4/2) and dark yellowish brown (10YR 4/4) mottles; moderate fine and very fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B21—32 to 39 inches; dark grayish brown (10YR 4/2) light silty clay loam; dark gray (10 YR 4/1) coatings on peds; few fine faint dark brown (10YR 3/3) and few fine distinct yellowish brown (10YR 5/4) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; friable; slightly acid; gradual smooth boundary.

B22—39 to 48 inches; brown (10YR 4/3) silty clay loam; gray (10YR 5/1) coatings on peds; brown (10YR 4/3) kneaded; common fine distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) and few fine distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine dark bodies; slightly acid; gradual smooth boundary.

B3—48 to 55 inches; grayish brown (10YR 5/2) light silty clay loam; few fine faint gray (10YR 5/1) mottles; common fine distinct yellowish brown (10YR 5/4) and strong brown (7.5YR 5/6) mottles; brown (10YR 5/3) kneaded; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine dark bodies; neutral; gradual smooth boundary.

C—55 to 60 inches; mixed gray (10YR 5/1) and brown (10YR 5/3) light silty clay loam; common fine faint strong brown (7.5YR 5/6) mottles; massive; friable; common fine dark bodies; neutral.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It is neutral to medium acid.

The B horizon ranges from very dark gray (10YR 3/1) in the upper part to brown (10YR 5/3) in the lower part.

Ely soils are associated on the landscape with Colo soils and formed in similar parent material. Ely soils have a silty clay loam B horizon that Colo soils lack. They are somewhat poorly drained, but Colo soils are poorly drained.

Gara Series

The Gara series consists of well drained to moderately well drained soils. These strongly sloping to steep soils are on side slopes in the uplands. They formed in glacial till under native vegetation of trees and grasses. Slopes are 9 to 25 percent.

In a representative profile the surface layer is very dark gray loam about 7 inches thick. The subsurface layer is dark grayish brown and very dark grayish brown loam about 5 inches thick. The subsoil extends to a depth of 40 inches. It is dark yellowish brown, medium loam in the upper part; dark yellowish brown, medium clay loam in the next part; and yellowish brown, medium clay loam in the lower part. The substratum is yellowish brown light clay loam. It is mildly alkaline.

Gara soils have moderately slow permeability and a high available water capacity. The subsoil is very low to low in available phosphorus and very low in available potassium. Unless limed, the surface layer is generally medium acid.

The Gara soils are highly erodible if used for row crops.

Representative profile of Gara loam, 9 to 14 percent slopes, 960 feet north and 140 feet east of the southwest corner of sec. 7, T. 73 N., R. 28 W. on a northwest-facing slope of 12 percent:

A1—0 to 7 inches; very dark gray (10YR 3/1) loam; dark gray (10YR 4/1) dry; weak very fine granular structure; friable; medium acid; clear smooth boundary.

A2—7 to 12 inches; dark grayish brown (10YR 4/2) and very dark grayish brown (10 YR 3/2) loam; light brownish gray (10 YR 6/2) dry; weak fine subangular blocky structure; friable; few ¼- to ½-inch pebbles; medium acid; clear smooth boundary.

B21t—12 to 17 inches; dark yellowish brown (10 YR 4/4) medium loam; brown (10YR 4/3) coatings on peds; few very dark grayish brown peds; moderate fine subangular blocky structure; friable; thin discontinuous clay films; few pebbles and stones; strongly acid; clear smooth boundary.

B22t—17 to 24 inches; dark yellowish brown (10YR 4/4) medium clay loam; brown (10YR 4/3) coatings on peds; moderate medium subangular blocky structure; firm; common fine distinct yellowish brown (10YR 5/6), few fine faint dark grayish brown (10YR 4/2) mottles; thin continuous clay films; few pebbles and stones; strongly acid; gradual smooth boundary.

B23t—24 to 33 inches; dark yellowish brown (10 YR 4/4) medium clay loam; few fine faint grayish brown (10YR 5/2) mottles and common fine distinct yellowish brown (10YR 5/6)mottles; weak medium prismatic structure parting to moderate medium subangular blocky; firm; thin continuous clay films; few pebbles and stones; few fine dark bodies; strongly acid; gradual smooth boundary.

B3t—33 to 40 inches; yellowish brown (10YR 5/4 and 5/6) medium clay loam; common fine distinct grayish brown (2.5Y 5/2) mottles; weak medium prismatic structure parting to moderate coarse subangular blocky and angular blocky; firm; few thin discontinuous clay films on vertical faces and in pores; few pebbles and stones; common dark bodies; slightly acid; clear smooth boundary.

C—40 to 60 inches; yellowish brown (10YR 5/4 and 5/6) light clay loam; many medium distinct grayish brown (2.5Y 5/2) mottles; massive and some vertical cleavage; firm; few dark bodies; few pebbles and stones; few carbonate concretions; calcareous; mildly alkaline.

The A1 horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). Texture ranges from loam to silt loam, but loam is the dominant texture.

The A2 horizon ranges from dark grayish brown (10YR 4/2) to very dark grayish brown (10YR 3/2). Texture ranges from loam to silt loam.

The B2 horizon ranges from dark yellowish brown (10YR 4/4) or brown (10YR 4/3) to yellowish brown (10YR 5/6). It is slightly acid to strongly acid.

The C horizon is slightly acid to mildly alkaline.

Gara soils are associated on the landscape with Pershing and Armstrong soils. They formed in parent material similar to that of Lindley and Shelby soils. They have more sand than the Pershing soils and less clay in the B2 horizon than the Armstrong soils. They have an A2 horizon that Shelby soils lack and have a thicker A1 horizon than Lindley soils.

179D—Gara loam, 9 to 14 percent slopes. This strongly sloping soil is on side slopes. It occurs as long, wide, and irregularly shaped areas. The profile is the one described as representative of the series.

Included with this soil in mapping are small areas of Armstrong and Clarinda soils. The most significant areas of these soils are identified by symbols on the soil map. Also included are some Gara soils with a silt loam surface layer.

This Gara soil is moderately suited to row crops and is well suited to hay and pasture. Many areas have been cleared and are used for pasture. The soil is susceptible to erosion. The organic-matter content in the plow layer is 2 to 3 percent. Capability unit IVe–3.

179D2—Gara loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on side slopes. It occurs as long, wide, and irregularly shaped areas. This soil has a profile similar to the one described as representative of the series, but the surface layer is 7 inches thick. In cultivated areas some material from the subsoil has been mixed with the surface layer. Erosion has removed the subsurface layer in most places, and the present plow layer is directly above the firm, dense subsoil.

Included with this soil in mapping are small areas of Armstrong and Clarinda soils. Small areas of severely eroded soils with a clay loam surface layer are also included.

This Gara soil is moderately suited to row crops and is well suited to hay and pasture. It becomes cloddy when tilled. It is more erodible than the uneroded Gara soil because it is in poorer physical condition. It crusts after a heavy rain, and seedling emergence is a problem. The organic-matter content in the plow layer is 1 to 2 percent. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required.

Erosion from runoff is the main hazard. Good residue management and applications of manure are needed. Removing the topsoil causes severe problems because of the unfavorable subsoil properties. Most areas are used as pasture. Capability unit IVe–3.

179E—Gara loam, 14 to 18 percent slopes. This moderately steep soil is on side slopes. It occurs as small to large, irregularly shaped areas.

Included with this soil in mapping are small areas of Armstrong soils and less sloping Gara soils. Significant spots of the clayey Armstrong soils are identified by spot symbols on the soil map. Some small areas of more severely eroded Gara soils are also included.

This Gara soil is not suited to row crops. It is moderately well suited to pasture and is well suited to woodland or wildlife. Most areas of this soil are wooded and are used for pasture. The soil is susceptible to erosion. The organic-matter content is 1 to 2 percent. Capability unit VIe–3.

179E2—Gara loam, 14 to 18 percent slopes, moderately eroded. This moderately steep soil is on side slopes. It occurs as individual, small to large, irregularly shaped areas. It has a profile similar to the one described as representative of the series, but the surface layer is thinner.

Included with this soil in mapping are small areas of Armstrong soils and less sloping or stronger sloping Gara soils. Significant spots of the clayey Armstrong soils are identified by spot symbols on the soil map. Some small areas of more severely eroded Gara soils are also included in mapping. Significant spots of these severely eroded soils are identified by spot symbols on the soil map.

This Gara soil is not suited to row crops. It is moderately well suited to pasture and is well suited to woodland or wildlife. Many areas are cleared and are used for pasture. The soil is susceptible to further erosion. The organic-matter content is 1 to 2 percent. Capability unit VIe–3.

179F—Gara loam, 18 to 25 percent slopes. This steep soil is on side slopes. Areas are very irregular in size and shape. Included in mapping are small areas of Armstrong soils and less sloping Gara soils. Also included are small areas of more severely eroded Gara soils.

This Gara soil is not suited to crops. It is severely limited for pasture because of the steep slopes. It is suited to woodland and wildlife habitat. Most areas are wooded and are used for pasture. The soil is susceptible to erosion. The organic-matter content is 1 to 2 percent. Capability unit VIIe–1.

993D2—Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded. This strongly sloping map unit is on side slopes. It is 50 percent Gara soils and 35 percent Armstrong soils. Areas are irregular in size and shape. The loam surface layer is less than 7 inches thick.

Included with this unit in mapping are small areas of more severely eroded soils, which are identified by spot symbols on the soil map.

This map unit is very poorly suited to row crops and is poorly suited to small grain and meadow. It is moderately well suited to pasture or woodland. It is susceptible to further erosion. The organic-matter content is 1 to 2 percent. Capability unit IVe–5.

993E2—Gara-Armstrong loams, 14 to 18 percent slopes, moderately eroded. This moderately steep map unit is on side slopes. It is 70 percent Gara soils and 30 percent Armstrong soils. The loam surface layer is less than 7 inches thick. Included in mapping are small areas of less eroded soils.

This map unit is not suited to row crops. It is moderately well suited to pasture and is well suited to woodland or wildlife. It is susceptible to further erosion. The organic-matter content is 1 to 2 percent. Capability unit VIe–3.

Grundy Series

The Grundy series consists of somewhat poorly drained soils. These gently sloping soils are on uplands and narrow convex ridgetops in the southeastern part of the county. They formed in loess under native vegetation of prairie grasses. Slopes are 2 to 5 percent.

In a representative profile the surface layer is black silty clay loam about 11 inches thick. The subsoil extends to a depth of 48 inches. It is very dark gray and dark grayish brown silty clay loam in the upper part, dark grayish brown and grayish brown silty clay in the next part, and grayish brown silty clay loam in the lower part. The substratum is grayish brown silty clay loam mottled with dark yellowish brown and yellowish brown. It is neutral.

Grundy soils have slow permeability and a high available water capacity. The subsoil is very low to low in available phosphorus and is low to medium in available potassium. Unless limed, the surface layer is generally slightly acid.

The Grundy soils are used for crops. They are subject to erosion.

Representative profile of Grundy silty clay loam, 2 to 5 percent slopes, 180 feet west and 700 feet north of the southeast corner of sec. 31, T. 71 N., R. 28 W. on a ridgetop with 3 percent slopes:

Ap—0 to 7 inches; black (10YR 2/1) light silty clay loam; very dark brown (10YR 2/2) when crushed; strong medium granular structure; friable; slightly acid; abrupt smooth boundary.

A1—7 to 11 inches; black (10YR 2/1) light silty clay loam; very dark brown (10YR 2/2) when crushed; moderate fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

B1—11 to 17 inches; very dark gray (10YR 3/1) silty clay loam; very dark grayish brown (10YR 3/2) when crushed; strong very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21t—17 to 24 inches; mixed very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) silty clay loam; strong very fine subangular blocky structure; firm; thin very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) clay films; common dark reddish brown oxide stains; medium acid; clear smooth boundary.

B22t—24 to 30 inches; dark grayish brown (10YR 4/2) silty clay; few fine prominent reddish brown (5YR 4/4) and yellowish red (5YR 4/6) and few fine distinct dark yellowish brown (10YR 4/4) mottles; fine and very fine subangular blocky structure; firm; thick continuous very dark gray (10YR 3/1) clay films; few dark bodies; medium acid; clear smooth boundary.

B23t—30 to 37 inches; grayish brown (10YR 5/2) light silty clay; yellowish brown (10YR 5/4) kneaded; many medium distinct dark yellowish brown (10YR 4/4) and few fine distinct brown (7.5YR 4/4) mottles; moderate medium to coarse prismatic structure parting to weak medium subangular blocky; firm; continuous very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) clay films; few dark bodies; medium acid; gradual smooth boundary.

B31t—37 to 48 inches; grayish brown (2.5Y 5/2) heavy silty clay loam; many fine prominent dark yellowish brown (10YR 4/4) and many medium prominent strong brown (7.5YR 5/6) mottles; weak medium to coarse prismatic structure parting to weak medium subangular blocky; firm; discontinuous clay films on cleavage faces; few dark bodies; neutral; gradual smooth boundary.

C—48 to 63 inches; grayish brown (2.5Y 5/2) light silty clay loam; brown (10YR 5/3) when kneaded; many medium distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles; massive with some vertical cleavage faces; firm; many medium dark bodies; neutral.

The Ap horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). Texture is light silty clay loam, but the range includes heavy silt loam. The Ap horizon ranges from medium acid to slightly acid.

The B2t horizon ranges from very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) to light brownish gray (10YR 6/2). It is 38 to 42 percent clay. The B2t horizon ranges from medium acid to slightly acid.

The C horizon ranges from grayish brown (2.5Y 5/2) to light olive gray (5Y 6/2). Reaction ranges from neutral to slightly acid.

Grundy soils are associated on the landscape with Shelby and Haig soils. They formed in parent material similar to that of Pershing soils. They have less sand than Shelby soils and are not so gray in the B horizon as Haig soils. They have a thicker, darker A horizon than Pershing soils.

364B—Grundy silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on ridgetops in the uplands. Areas vary greatly in size and shape. Included in mapping are small areas of nearly level Haig soils.

This Grundy soil is well suited to row crops. The hazard of erosion is slight because of the gentle slopes. The organic-matter content is 2 to 4 percent. Capability unit IIe–3.

Haig Series

The Haig series consists of poorly drained soils. These nearly level soils are on upland flats. They formed in loess under native vegetation of prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam about 18 inches thick. The subsoil extends to a depth of 65 inches. It is very dark gray, firm heavy silty clay loam in the upper part; dark gray to olive gray, firm silty clay in the next part; and olive gray, friable silty clay loam in the lower part.

Haig soils have slow to very slow permeability and a high available water capacity. The subsoil is low in available phosphorus and available potassium. Unless limed, the surface layer is slightly acid.

The Haig soils are used primarily for cultivated crops. The major limitation is wetness.

Representative profile of Haig silty clay loam, 0 to 2 percent slopes, 630 feet west and 1,140 feet south of northeast corner of sec. 29, T. 71 N., R. 29 W. on a nearly level divide:

Ap—0 to 7 inches; black (10YR 2/1) light silty clay loam; cloddy structure parting to weak fine granular; friable; slightly acid; abrupt smooth boundary.

A12—7 to 13 inches; black (10YR 2/1) light silty clay loam; moderate very fine subangular blocky structure parting to weak fine granular; friable; slightly acid; gradual smooth boundary.

A3—13 to 18 inches; black (10YR 2/1) medium silty clay loam; few fine faint very dark gray (10YR 3/1) mottles; weak fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B1t—18 to 24 inches; very dark gray (10YR 3/1) heavy silty clay loam; few fine distinct yellowish brown (10YR 5/4) mottles; continuous clay films; strong fine subangular blocky structure; firm; medium acid; clear smooth boundary.

B21t—24 to 30 inches; dark gray (10YR 4/1) light silty clay; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; continuous ped coatings of (10YR 3/1) clay films; moderate fine subangular blocky structure; firm; medium acid; gradual smooth boundary.

B22t—30 to 35 inches; dark gray (5Y 4/1) medium silty clay; many fine distinct yellowish brown (10YR 5/4) and few fine distinct brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; firm; discontinuous very dark gray (10YR 3/1) coatings on some peds; thick continuous clay films; few fine dark bodies; medium acid; gradual smooth boundary.

B23t—35 to 44 inches; olive gray (5Y 5/2) light silty clay; many fine distinct strong brown (7.5YR 5/6) and gray (10YR 5/1) mottles; weak fine prismatic structure parting to moderate medium subangular blocky; firm; discontinuous very dark gray (10YR 3/1) and dark gray (10YR 4/1) clay films mainly on prisms; few fine dark bodies; slightly acid; gradual smooth boundary.

B31t—44 to 54 inches; olive gray (5Y 5/2) medium silty clay loam; many fine distinct brown (7.5YR 4/4) mottles; weak medium prismatic structure; friable; very dark gray (10YR 3/1) clay films on prisms; many fine dark bodies; slightly acid; gradual smooth boundary.

B32t—54 to 65 inches; olive gray (5Y 5/2) medium silty clay loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure; friable; thin discontinuous clay films on prisms; few dark bodies; slightly acid.

The Ap horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). Texture is dominantly light silty clay loam but ranges to include silt loam. It is 6 to 10 inches thick.

The B horizon ranges from very dark gray (10YR 3/1) to light olive gray (5Y 6/2). It ranges from slightly acid to strongly acid. Texture of the B2 horizon ranges from heavy silty clay loam to silty clay.

Haig soils are associated on the landscape with Grundy and Sperry soils and formed in similar parent materials. They are darker and deeper and have more clay in the B2 horizon than Grundy soils. Haig soils lack the A2 horizon that Sperry soils have.

362—Haig silty clay loam, 0 to 2 percent slopes. This nearly level soil is on broad flat uplands. It generally occurs in long and wide areas. The profile of this soil is the one described as representative of the series. Included in mapping are small areas of Sperry soils and Grundy soils.

This Haig soil is well suited to cultivated crops. It is susceptible to wetness unless drained. The organic-matter content is 4 to 6 percent. Capability unit IIw–2.

Humeston Series

The Humeston series consists of poorly drained to very poorly drained soils that formed in alluvium. These soils are nearly level. The native vegetation was wet prairie grasses. Areas of these soils range from 5 to 20 acres in size. Slopes are 0 to 2 percent.

In a representative profile, the surface layer extends to a depth of about 18 inches. The upper 8 inches is black silty clay loam, and the lower 5 inches is very dark gray to dark gray silt loam. The subsurface layer is dark gray silt loam 9 inches thick and mottled very dark gray and dark gray silty clay loam about 4 inches thick. The subsoil is black, very dark gray, and dark grayish brown silty clay and silty clay loam. It extends to a depth of 5 feet or more.

Humeston soils have moderately slow permeability in the upper part and very slow permeability in the lower part. Available water capacity is high. The subsoil is medium to low in available phosphorus and very low in available potassium. Unless limed, the surface layer is slightly acid.

The Humeston soils are used primarily for cultivated crops. The major limitation is wetness. The Humeston soils are seasonally wet because the water table is high or the soils are flooded. Drainage and protection from flooding are needed.

Representative profile of Humeston silty clay loam, 0 to 2 percent slopes, 2,190 feet south and 1,970 feet west of the northeast corner of sec. 30, T. 71 N., R. 31 W. on nearly level alluvium:

A11—0 to 8 inches; black (10YR 2/1) light silty clay loam; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A12—8 to 13 inches; very dark gray (10YR 3/1) silt loam; weak fine subangular blocky structure parting to fine granular; friable; discontinuous gray (10YR 6/1) and light gray (10YR 7/1) ped coatings when dry; medium acid; clear smooth boundary.

A21—13 to 16 inches; dark gray (10YR 4/1) silt loam; moderate thin platy structure; friable; discontinuous light gray (10YR 7/1) ped coatings when dry; strongly acid; clear smooth boundary.

A22—16 to 22 inches; dark gray (10YR 4/1) silt loam; moderate thin platy structure; friable; continuous light gray (10YR 7/1) ped coatings when dry; medium acid; clear smooth boundary.

A23—22 to 26 inches; mottled very dark gray (10YR 3/1) and dark gray (10YR 4/1) light silty clay loam; weak medium subangular blocky structure; friable; discontinuous light gray (10YR 7/1) ped coatings when dry; medium acid; clear smooth boundary.

B1—26 to 30 inches; black (10YR 2/1) heavy silty clay loam; weak medium subangular blocky structure; friable; strongly acid; clear smooth boundary.

B21t—30 to 40 inches; black (10YR 2/1) light silty clay; weak medium prismatic structure; firm; thin clay films; slightly acid; gradual smooth boundary.

B22tg—40 to 50 inches; very dark gray (10YR 3/1) light silty clay; weak medium prismatic structure; firm; few thin discontinuous clay films; some gray (10YR 5/1) coatings; slightly acid; gradual smooth boundary.

B3tg—50 to 63 inches; mottled very dark gray (10YR 3/1) and dark grayish brown (10YR 4/2) heavy silty clay loam; weak medium prismatic structure; firm; slightly acid.

The A1 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/1). Texture is dominantly light silty clay loam but ranges to include heavy silt loam.

The A2 horizon ranges from dark gray (10YR 4/1) to gray (10YR 5/1).

The B2t horizon ranges from black (N 2/0) to very dark gray (10YR 3/1). The texture ranges from heavy silty clay loam to silty clay.

Humeston soils are associated on the landscape with Colo, Nodaway, and Wabash soils. They formed in parent material similar to that of Vesser soils. Humeston soils have a dark gray silt loam A2 horizon that is lacking in Colo, Nodaway, and Wabash soils. They have a thinner A2 horizon and a more clayey B horizon than Vesser soils.

269—Humeston silty clay loam, 0 to 2 percent slopes. This nearly level soil is on low bottom land benches and alluvial areas in larger drainageways. Areas are generally 5 to 20 acres in size and vary in shape. Included in mapping are small areas of Colo and Wabash soils.

This Humeston soil is suited to row crops or pasture. It is susceptible to wetness. Drainage is needed because the soil generally dries out slowly in spring and after rains. The organic-matter content is 2 to 4 percent. Capability unit IIIw-3.

Judson Series

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

In a representative profile the surface layer is black, dark brown, very dark brown, and very dark grayish brown silty clay loam about 28 inches thick. The subsoil extends to a depth of 46 inches. It is dark brown silty clay loam in the upper part and brown silty clay loam in the lower part. The substratum is brown light silty clay loam mottled with grayish brown and yellowish brown.

Judson soils have moderate permeability and a high available water capacity. The subsoil is low in available phosphorus and available potassium. Unless limed, the surface layer is generally slightly acid.

The Judson soils are used primarily for cultivated crops. The hazard of erosion is slight.

Representative profile of Judson silty clay loam, 2 to 5 percent slopes, 2,450 feet south and 1,560 feet east of northwest corner of sec. 12, T. 73 N., R. 29 W.

Ap—0 to 9 inches; black (10YR 2/1) light silty clay loam; very dark grayish brown (10YR 3/2) when kneaded; dark grayish brown (10YR 4/2) when dry; cloddy structure parting to weak medium granular; friable; slightly acid; clear smooth boundary.

A12—9 to 15 inches; very dark brown (10YR 2/2) light silty clay loam; very dark grayish brown (10YR 3/2) kneaded; dark grayish brown (10YR 4/2) dry; weak fine granular and weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A13—15 to 22 inches; mixed very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) light silty clay loam; very dark grayish brown (10YR 3/2) kneaded; grayish brown (10YR 5/2) dry; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A3—22 to 28 inches; mixed very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) silty clay loam; dark brown (10YR 3/3) kneaded; brown (10YR 5/3) dry; weak fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B2—28 to 35 inches; dark brown (10YR 3/3) silty clay loam; dark yellowish brown (10YR 4/4) kneaded; few fine faint dark yellowish brown (10YR 4/4) mottles; moderate medium subangular blocky structure; friable; very few thin clay coats; few fine dark bodies; slightly acid; gradual smooth boundary.

B3—35 to 46 inches; brown (10YR 4/3) silty clay loam; dark yellowish brown (10YR 4/4) kneaded; few fine faint grayish brown (10YR 5/2) and few fine distinct yellowish brown (10YR 5/6) mottles; weak coarse and medium subangular blocky structure; friable; common fine dark bodies; slightly acid; gradual smooth boundary.

C—46 to 60 inches; brown (10YR 4/3) light silty clay loam; dark yellowish brown (10YR 4/4) kneaded; common fine faint grayish brown (10YR 5/2) and common fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; common fine dark bodies; neutral.

The A horizon is dominantly silty clay loam but ranges to silt loam. It is neutral to medium acid.

The B horizon ranges from slightly acid to medium acid.

Judson soils are associated on the landscape with Sharpsburg and Macksburg soils. They formed in parent material similar to that of Olmitz and Ely soils. They have less sand than the Olmitz soils. Judson soils are well drained to moderately well drained, but Ely soils are somewhat poorly drained. Judson soils formed in alluvial sediments, and Sharpsburg and Macksburg soils formed in loess.

8B—Judson silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on fan-shaped alluvial deposits at the mouth of small hillside waterways and on narrow depositional foot slopes. It occurs as small areas in many parts of the county along the streams. These areas are typically adjacent to and between the steeper side slopes and the alluvial first and second bottoms.

Included with this soil in mapping are small areas of gently sloping, more poorly drained alluvial soils near the lower border at the lower elevations of this soil.

This soil is well suited to row crops. Most areas are used for row crops. Some are used for pasture and hay. The soil is susceptible to erosion. The organic-matter content is 4 to 6 percent. Capability unit IIe-2.

Kennebec Series

The Kennebec series consists of moderately well drained soils. These nearly level soils are on bottom land. The Kennebec soils formed in alluvium under vegetation of tall prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black to very dark gray silt loam about 30 inches thick. The substratum is very dark gray silt loam with few dark brown mottles.

The Kennebec soils have moderate permeability and a high available water capacity. The subsoil is low in available phosphorus and is very low to low in available potassium. Unless limed, the surface layer is generally slightly acid.

The Kennebec soils are used primarily for cultivated crops. The major hazard for crops is occasional flooding.

Representative profile of Kennebec silt loam, 0 to 2 percent slopes, 610 feet west and 2,500 feet south of the northeast corner of sec. 24, T. 73 N., R. 29 W. in a pasture on the bottom land of the Thompson branch of the Grand River:

A11—0 to 2 inches; very dark gray (10YR 3/1) silt loam; weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—2 to 12 inches; black (10YR 2/1) silt loam; very dark brown (10YR 2/2) kneaded; weak fine subangular blocky structure; friable; slightly acid; diffuse smooth boundary.

A13—12 to 21 inches; black (10YR 2/1) silt loam; very dark brown (10YR 2/2) kneaded; weak fine subangular blocky structure; friable; slightly acid; diffuse smooth boundary.

A14—21 to 30 inches; very dark gray (10YR 3/1) silt loam; very dark gray (10YR 2/2) kneaded; weak fine subangular blocky structure parting to fine granular; friable; slightly acid; diffuse smooth boundary.

C1—30 to 40 inches; very dark gray (10YR 3/1) silt loam; very dark grayish brown (10YR 3/2) kneaded; massive; friable; slightly acid; diffuse smooth boundary.

C2—40 to 60 inches; very dark gray (10YR 3/1) silt loam; very dark grayish brown (10YR 3/2) kneaded; few fine dark brown (10YR 3/3) mottles; weak fine subangular blocky structure parting to fine granular; friable; slightly acid.

The Ap or A11 horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The A horizon is neutral or slightly acid.

The C horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2).

Kennebec soils are associated on the landscape with

Colo and Nodaway soils. They are less clayey than Colo soils. In contrast with Nodaway soils, they are not stratified.

212—Kennebec silt loam, 0 to 2 percent slopes. This nearly level soil is on bottom land in the stream valleys. Areas vary widely in size, and some are as large as 60 inches or more. Included in mapping are small areas of Colo and Nodaway soils.

This Kennebec soil is well suited to row crops. It is subject to common flooding. The organic-matter content is 4 to 6 percent. Capability unit I–2.

Keswick Series

The Keswick series consists of moderately well drained soils. These moderately sloping soils are on upper side slopes and narrow ridges of the uplands. They formed in highly weathered glacial till under native vegetation of trees. Slopes are 5 to 9 percent.

In a representative profile the surface layer is very dark gray friable loam about 3 inches thick. The subsurface layer is grayish brown to brown friable loam about 8 inches thick. The subsoil extends to a depth of 64 inches. It is brown, firm clay loam in the upper part; brown, strong brown, grayish brown, and reddish brown, very firm clay in the next part; and mottled yellowish brown, grayish brown, and brown, firm clay loam in the lower part.

Keswick soils have slow permeability and a moderate available water capacity. The subsoil is very low in available phosphorus and available potassium. Unless limed, the surface layer is slightly acid.

The Keswick soils are used primarily for timber and pasture. The major limitations are low fertility and the clay subsoil.

Representative profile of Keswick loam, 5 to 9 percent slopes, 660 feet north and 3,240 feet west of the southeast corner of sec. 12, T. 71 N., R. 28 W. on an east-facing ridgetop of 7 percent:

A1—0 to 3 inches; very dark gray (10YR 3/1) loam; weak fine granular and weak very thin platy structure; friable; slightly acid; abrupt smooth boundary.

A21—3 to 7 inches; grayish brown (10YR 5/2) loam; pale brown (10YR 6/3) dry; weak thin platy and weak fine granular structure; friable; very strongly acid; clear smooth boundary.

A22—7 to 11 inches; brown (10YR 5/3) loam; weak fine subangular blocky structure; friable; thin discontinuous light gray (10YR 7/2) coatings; strongly acid; clear smooth boundary.

IIB21t—11 to 17 inches; brown (7.5YR 4/4) clay loam; medium subangular blocky structure; firm; thin discontinuous light gray (10YR 7/2) coatings; very strongly acid; clear smooth boundary.

IIB22t—17 to 24 inches; brown (7.5YR 4/4) clay; common fine distinct red (2.5YR 4/6) and brown (7.5YR 5/2) mottles; medium subangular blocky structure; very firm; thin continuous clay films on most peds; very strongly acid; clear smooth boundary.

IIB23t—24 to 29 inches; mottled brown (7.5YR 5/4) and reddish brown (5YR 4/4) clay; medium subangular blocky structure; very firm; thin continuous clay films on some peds; very strongly acid; clear smooth boundary.

IIB24t—29 to 35 inches; mottled strong brown (7.5YR 5/6), grayish brown (10YR 5/2), and yellowish brown (10YR 5/4) clay; medium prismatic structure parting to weak fine subangular blocky; very firm; few soft dark bodies; few thin discontinuous clay films on peds and old root channels; strongly acid; clear smooth boundary.

IIB31—35 to 45 inches; mottled yellowish brown (10YR 5/6), grayish brown (10YR 5/2), and brown (7.5YR 4/2) clay loam; medium prismatic structure parting to weak medium subangular blocky; very firm; few soft dark bodies; few thin discontinuous clay films in some old root channels; slightly acid; gradual smooth boundary.

IIB32—45 to 64 inches; yellowish brown (10YR 5/6) clay loam; brown (10YR 5/3) coatings on peds; weak medium prismatic structure parting to medium angular blocky; firm; few thin discontinuous clay films in root channels; some dark coatings on prism and cleavage faces; neutral.

The A1 horizon ranges from very dark brown (10YR 2/2), and very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). Texture is typically loam but ranges to include silt loam.

The A2 horizon ranges from grayish brown (10YR 5/2) to yellowish brown (10YR 5/4). Texture ranges from loam to silt loam.

Keswick soils are associated on the landscape with Lindley and Weller soils. They formed in parent material similar to that of Adair and Armstrong soils. They have a thicker A2 horizon than Armstrong soils. In contrast with Adair soils, they have an A2 horizon. They are more clayey than Lindley soils. Keswick soils are more sandy and clayey than Weller soils formed in different parent material.

425C—Keswick loam, 5 to 9 percent slopes. This moderately sloping soil is on side slopes and on the ends of ridges in the timbered uplands. Areas are irregular in shape and size.

Included with this soil in mapping are small areas of Weller and Lindley soils. Also included are small, severely eroded areas.

This Keswick soil is suited to row crops if erosion is controlled. It is susceptible to erosion. Runoff is rapid. Tilth is poor in some places. Tile helps control water seepage from soils upslope. The organic-matter content is less than 1 percent. Capability unit IIIe–6.

Ladoga Series

The Ladoga series consists of gently sloping to strongly sloping, moderately well drained soils. These soils formed in loess on uplands under prairie grass and timber vegetation. They occupy a transitional area adjacent to the Sharpsburg soils, which developed under prairie vegetation. Ladoga soils are on ridgetops with 2 to 5 percent slopes and upper side slopes with 5 to 14 percent slopes. They are also gently sloping and moderately sloping on high benches next to streams. In some areas they occupy entire side slopes and merge with alluvial soils at the base of the slope.

The surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark grayish brown and grayish brown silt loam 4 inches thick. The subsoil is firm, brown and dark yellowish brown light silty clay loam and silty clay about 46 inches thick. The substratum is a friable, grayish brown silty clay loam.

Ladoga soils have moderately slow permeability and a high available water capacity. Fertility is moderate. The subsoil is medium in available phosphorus, but is very low in available potassium. Runoff is moderate to rapid, depending on steepness of slope. Unless limed, the surface layer is typically slightly acid.

These soils are fertile and are easily tilled. They are suited to crops, and most of the acreage is in crops. A small acreage, however, is managed with more sloping adjacent soils as pasture or woodland. The steeper Ladoga soils have moderate and severe limitations. The major management problem is erosion.

Representative profile of Ladoga silt loam, 5 to 9 percent slopes, 2,140 feet north and 1,830 feet east of the southwest corner of sec. 34, T. 71 N., R. 31 W. on a north-facing slope of 6 percent near a cemetery:

A1—0 to 7 inches; very dark gray (10YR 3/1) silt loam; moderate fine subangular blocky structure parting to weak fine granular; friable; neutral; clear smooth boundary.

A2—7 to 11 inches; mixed grayish brown (10YR 5/2) and dark grayish brown (10YR 4/2) silt loam; light gray (10YR 7/2) and light brownish gray (10YR 6/2) dry; weak medium platy structure parting to moderate very fine subangular blocky; friable; neutral; clear smooth boundary.

B1—11 to 15 inches; brown (10YR 4/3) light silty clay loam; weak fine subangular blocky structure; friable; common fine brown (10YR 5/3) silt coatings; slightly acid; clear smooth boundary.

B21t—15 to 19 inches; brown (10YR 4/3) medium silty clay loam; weak medium subangular blocky structure parting to strong fine subangular blocky; friable; common dark grayish brown (10YR 4/2) silt coatings; thin discontinuous clay films; strongly acid; clear smooth boundary.

B22t—19 to 25 inches; dark yellowish brown (10YR 4/4) light silty clay; brown (10YR 4/3) coatings on peds; moderate medium and fine subangular and angular blocky structure; firm; few grayish brown (10YR 5/2) silt coatings; nearly continuous clay films; very strongly acid; gradual smooth boundary.

B23t—25 to 33 inches; brown (10YR 4/3) light silty clay; few fine faint brown (7.5YR 4/4) and few fine faint grayish brown (2.5Y 5/2) mottles; fine subangular and angular blocky structure; firm; few grayish brown (10YR 5/2) silt coatings; thick discontinuous clay films; very strongly acid; gradual smooth boundary.

B31t—33 to 45 inches; brown (10YR 5/3) medium silty clay loam; common fine yellowish red (5YR 4/6) and grayish brown (2.5Y 5/2) mottles that increase in number with depth; weak medium prismatic structure parting to weak fine and medium angular blocky; friable; few thin discontinuous clay films; common fine dark bodies; strongly acid; gradual smooth boundary.

B32t—45 to 57 inches; brown (10YR 5/3) light silty clay loam; common fine and medium faint grayish brown (2.5Y 5/2) mottles; weak medium prismatic structure; friable; few thin discontinuous clay films and flows in pores; medium acid; gradual smooth boundary.

C—57 to 65 inches; grayish brown (2.5Y 5/2) light silty clay loam; common medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; common dark bodies; neutral.

The A1 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2).

The A2 horizon ranges from very dark grayish brown (10YR 3/2) to grayish brown (10YR 5/2). It ranges from slightly acid to neutral.

The B2t horizon is 36 to 42 percent clay.

The C horizon ranges from brown (10YR 5/3) and grayish brown (2.5Y 5/2) to yellowish brown (10YR 5/4). Texture ranges from silty clay loam to silt loam.

Ladoga soils are associated on the landscape with Gara and Armstrong soils. They formed in parent material similar to that of Sharpsburg soils. They have an A2 horizon that Sharpsburg soils lack. They have less clay than Armstrong soils and less sand than Gara soils.

76B—Ladoga silt loam, 2 to 5 percent slopes. This gently sloping soil is on convex ridgetops near the larger streams in the western part of the county. It occurs as small, narrow, and irregularly shaped areas.

Included with this soil in mapping are small areas of loamy sand. If large enough to affect management, these sandy areas are identified by spot symbols on the soil map.

This Ladoga soil is well suited to cultivated crops. Erosion is a hazard. The organic-matter content is 2 to 4 percent. Capability unit IIe-1.

76C—Ladoga silt loam, 5 to 9 percent slopes. This moderately sloping soil is on sharply convex ridgetops and upper side slopes near the larger streams in the western part of the county. It occurs as small, narrow, and irregularly shaped areas. The profile of this soil is the one described as representative of the series. The plow layer contains 2 to 3 percent organic matter.

Included with this soil in mapping are small areas of gray clay, reddish clay, sandy spots, and undifferentiated glacial till. If large enough to affect management, these areas are identified by spot symbols on the soil map.

This Ladoga soil is suited to cultivated crops if erosion is controlled. Erosion is a hazard. Capability unit IIIe–2.

76C2—Ladoga silt loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on high, convex ridgetops and in narrow bands downslope from the gently sloping Ladoga soils. The slopes are dominantly complex because side slope drainageways run into this soil. This soil has a profile similar to the one described as representative of the series, but it has a 7-inch plow layer. Erosion has removed part of the surface and subsurface layers. In places plowing has mixed what is left of these layers with material from the subsoil. The present plow layer is generally very dark grayish brown silt loam but ranges to light silty clay loam. It contains 1 to 3 percent organic matter. The subsurface layer has been lost in most places.

Included with this soil in mapping are very small areas of less sloping Ladoga soils and areas of adjacent Gara soils.

This soil is suited to crops. Most of the acreage is cultivated. Some areas are managed with adjacent pasture. The thin surface layer and moderate slopes slow the water absorption rate and increase runoff. Sheet erosion is the major management problem. The rapid runoff forms small gullies in areas where heads of drainageways extend into this soil. Tilth is poor in a few areas, and the plow layer becomes cloddy if the brown subsoil is exposed. Good residue management, such as returning crop residues to the soil and applications of manure, is needed to maintain tilth and crop production. Management of pasture requires greater application of fertilizer and erosion control practices than on the uneroded soils. Capability unit IIIe–2.

76D—Ladoga silt loam, 9 to 14 percent slopes. This strongly sloping soil is on side slopes in the timbered areas in the western two-thirds of the county. Areas are small and vary in size and shape.

Included with this soil in mapping are small areas of less sloping or more eroded Ladoga soils and adjacent Gara soils on similar slopes. Also included are small areas of gray clay, reddish clay, sand, and undifferentiated glacial till. These small areas are identified by spot symbols on the soil map.

This Ladoga soil is suited to occasional row crops if erosion is controlled. It is susceptible to sheet and gully erosion if cropped. The organic-matter content is 2 to 4 percent. Capability unit IIIe–2.

T76B—Ladoga silt loam, benches, 2 to 5 percent slopes. This gently sloping soil is on benches that extend into the bottom land. The loess on benches differs from that on uplands. It is underlain at a depth of 8 to 10 feet by sandy alluvial sediments. Areas are generally small, but some are large.

This Ladoga soil is very well suited to row crops, but it is susceptible to slight erosion. Management is difficult because of the short, irregular slopes. The soil has low potential for landfill and sewage lagoon sites because of the hazard of ground water pollution. The organic-matter content is 2 to 4 percent. Capability unit IIe–1.

T76C—Ladoga silt loam, benches, 5 to 9 percent slopes. This moderately sloping soil is on benches that extend into the bottom land. The loess on benches differs from that on uplands. It is underlain at a depth of 6 to 8 feet by sandy alluvial sediments. Areas are generally small.

This Ladoga soil is suited to cultivated crops if erosion is controlled. Erosion is a hazard. Management is difficult because of the short, irregular slopes. The soil has low potential for landfill and sewage lagoon sites because of the danger of ground water pollution. The organic-matter content is 2 to 4 percent. Capability unit IIIe–2.

Lamoni Series

The Lamoni series consists of somewhat poorly drained soils. These moderately sloping and strongly sloping soils are on side slopes. The Lamoni soils formed in weathered glacial till under native vegetation of prairie grasses. Slopes are 5 to 14 percent.

In a representative profile the surface layer is black and very dark grayish brown, friable silty clay loam about 12 inches thick. The subsoil extends to a depth of 52 inches. It is brown and dark grayish brown to grayish brown, firm clay in the upper part; grayish brown, very firm clay in the next part; and light gray, yellowish brown and light brownish gray, very firm clay loam in the lower part. The substratum is mottled strong brown and light gray, firm medium clay loam.

Lamoni soils have slow to very slow permeability and a high available water capacity. The subsoil is low in available phosphorus and low to medium in available potassium. Unless limed, the surface layer is medium acid.

The Lamoni soils are used primarily for row crops in the moderately sloping areas and for hay and pasture on the strongly sloping side slopes. The major limitation for crops or pasture is erosion, but wetness can also be a problem.

Representative profile of Lamoni silty clay loam, 5 to 9 percent slopes, 750 feet south and 270 feet east of the northwest corner of sec. 10, T. 71 N., R. 30 W.:

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) dry; very fine subangular blocky structure parting to very fine granular; friable; medium acid; clear smooth boundary.

A3—8 to 12 inches; very dark grayish brown (10YR 3/2) light silty clay loam; few black (10YR 2/1) peds; very fine to fine subangular blocky structure; friable; medium acid; clear smooth boundary.

IIB1t—12 to 15 inches; brown (10YR 4/3) light clay; dark grayish brown (10YR 4/2) coatings on peds; few fine distinct strong brown (7.5YR 5/6) mottles; strong fine subangular blocky structure; firm; few thin discontinuous clay films; strongly acid; gradual smooth boundary.

IIB21t—15 to 19 inches; dark grayish brown to grayish brown (10YR 4/2 and 5/2) clay; many fine distinct strong brown (7.5YR 5/6) mottles; strong fine subangular blocky structure; very firm; thin discontinuous clay films; medium acid; gradual smooth boundary.

IIB22t—19 to 25 inches; grayish brown (2.5Y

5/2) clay; common fine distinct yellowish brown (10YR 5/6) and few fine distinct strong brown (7.5YR 5/6) mottles; strong fine and medium subangular blocky structure; very firm; thick continuous clay films; medium acid; gradual smooth boundary.

IIB23t—25 to 31 inches; grayish brown (10YR 5/2) light clay; common fine distinct yellowish brown (10YR 5/6) and few fine distinct strong brown (7.5YR 5/6) mottles; strong fine and medium subangular blocky structure; very firm; thin discontinuous clay films; dark apparent organic-matter stains in old root channels; medium acid; gradual smooth boundary.

IIB31t—31 to 38 inches; mottled grayish brown (2.5Y 5/2), light gray (5Y 6/1), and yellowish brown (10YR 5/6) heavy clay loam; moderate medium prismatic structure parting to weak medium subangular blocky; few fine dark bodies; very firm; thin discontinuous clay films; few pebbles; medium acid; gradual smooth boundary.

IIB32t—38 to 52 inches; light brownish gray (2.5Y 6/2) medium clay loam; common fine distinct yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to weak medium subangular blocky; very firm; thin discontinuous grayish brown (2.5Y 5/2) clay films; medium acid; gradual smooth boundary.

IIC—52 to 71 inches; mottled strong brown (7.5YR 5/6) and light gray (5Y 6/1) medium clay loam; massive; firm; few pebbles; soft dark bodies; some white weathered minerals; medium acid.

The texture of the Ap horizon is typically silty clay loam but ranges to loam. The Ap horizon ranges from medium to strongly acid.

The IIC horizon ranges from strong brown (7.5YR 5/6) to yellowish brown (10YR 5/6), with light gray (5Y 6/1) mottles. The texture ranges from heavy loam to clay loam. The moderately eroded Lamoni soils are outside the range defined for the series because they lack a mollic epipedon. This difference, however, does not alter the use and behavior of the soils.

Lamoni soils are associated on the landscape with Clarinda and Shelby soils. They formed in parent material similar to that of Clarinda soils. They have a thinner clay layer and more sand in the lower substratum than Clarinda soils and have more clay in the B horizon than Shelby soils.

822C—Lamoni silty clay loam, 5 to 9 percent slopes. This moderately sloping soil is on short side slopes, narrow ridges, and at the heads of upland drainageways. Areas are small in size and irregular in shape. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of Clarinda and Shelby soils. In many places the surface layer is more clayey than the one in the representative profile because it has been mixed with the clay subsoil.

This Lamoni soil is suited to occasional row crops if erosion is controlled, but it is better suited to hay and pasture. Erosion is a hazard. Wetness is a problem in some areas because the soil is slowly permeable. The organic-matter content is 2 to 4 percent. Capability unit IIIe-4.

822C2—Lamoni silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on short side slopes, narrow ridges, and at the heads of upland drainageways. Areas are small in size and irregular in shape. This soil has a profile similar to the one described as representative of the series, but the surface layer is only 3 to 7 inches thick.

Included with this soil in mapping are small areas of Clarinda and Shelby soils. In many places the surface layer is more clayey than the one in the representative profile because it has been mixed with the clay subsoil. Also included are small, severely eroded areas.

This Lamoni soil is suited to occasional row crops if erosion and seepy spots are controlled. Erosion and wetness are hazards because of the very slow permeability of the subsoil. Tiling works well in some areas. The organic-matter content is 2 to 4 percent. Capability unit IIIe-4.

822D—Lamoni silty clay loam, 9 to 14 percent slopes. This strongly sloping soil is on short convex slopes along waterways and around heads of drainageways of the uplands. Areas are irregular in shape and are 5 to 25 acres in size.

Included with this soil in mapping are small areas of Clarinda, Adair, and Shelby soils. Also included are some small severely eroded areas, which are identified by spot symbols on the soil map.

This Lamoni soil is better suited to pasture than row crops. Erosion is a hazard because of the strong slopes. Because the soil is somewhat poorly drained and has a very slowly permeable subsoil, some areas are wet. The organic-matter content is 2 to 4 percent. Capability unit IVe-4.

822D2—Lamoni silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on short rounded slopes along waterways and around heads of drainageways in uplands. Areas are 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, but the surface layer is thinner.

Included with this soil in mapping are small areas of Clarinda and Shelby soils. Also included are small sandy areas that are identified by spot symbols on the soil map if they are large enough.

This Lamoni soil is better suited to hay or pasture than to row crops. Erosion is a hazard. Because the soil is somewhat poorly drained and has a very slowly permeable subsoil, some areas are wet. The organic-matter content is 2 to 4 percent. Capability unit IVe-4.

Lindley Series

The Lindley series consists of moderately well drained upland soils that formed in clay loam glacial till under native vegetation of trees. These soils have a thin surface layer and a grayish subsurface layer. If cultivated, they have a distinct, light colored surface layer when dry. Slopes are 9 to 25 percent but are mostly 15 percent or steeper. The strongly sloping soils are on ridges, and the moderately steep to steep soils are on side slopes. Areas are large and occur mostly in the steeper, more densely timbered areas. The present vegetation is dominantly oak timber.

The surface layer is very dark grayish brown, friable loam about 2 inches thick. The subsurface layer is dark grayish brown, friable loam about 4 inches thick. The subsoil is firm, brown and yellowish brown clay loam. It is about 26 inches thick. The lower part is mixed with grayish brown and mottled with contrasting brown and gray. It is mostly firm. The substratum is yellowish brown, firm clay loam mottled with grayish brown. Calcium carbonates are at a depth of about 32 inches.

Lindley soils have a high available water capacity and moderately slow permeability. If the timber is removed, runoff severely erodes the surface layer unless grass vegetation is established. The subsoil is very low in available phosphorus and low in available potassium. Unless limed, the surface layer is medium to strongly acid.

The less sloping Lindley soils are suited to limited use as cropland. The steeper areas are in timber. Roots can penetrate these soils, but root growth is limited by the slow absorption of water and low available plant nutrients.

Representative profile of Lindley loam, 14 to 18 percent slopes, 210 feet west and 610 feet south of the northeast corner of sec. 25, T. 72 N., R. 29 W.

A1—0 to 2 inches; very dark grayish brown (10YR 3/2) loam; moderate very fine granular structure; friable; medium acid; abrupt smooth boundary.

A2—2 to 6 inches; dark grayish brown (10YR 4/2) loam; weak thin platy structure parting to weak fine granular; friable; strongly acid; clear smooth boundary.

B1—6 to 10 inches; brown (10YR 4/3) heavy loam; moderate fine granular and moderate fine subangular blocky structure; friable; strongly acid; clear smooth boundary.

B21t—10 to 15 inches; yellowish brown (10YR 5/6) light clay loam; moderate fine and very fine subangular blocky structure; firm; few thin discontinuous clay films; strongly acid; clear smooth boundary.

B22t—15 to 26 inches; yellowish brown (10YR 5/4) clay loam; moderate fine angular blocky structure; firm; thin continuous dark yellowish brown (10YR 4/4) clay films; strongly acid; clear smooth boundary.

B23t—26 to 32 inches; yellowish brown (10YR 5/6) clay loam; common fine distinct grayish brown (10YR 5/2) mottles; weak medium and fine subangular blocky structure; firm; thin discontinuous clay films; medium acid; clear smooth boundary.

C—32 to 60 inches; yellowish brown (10YR 5/4) clay loam; common medium faint grayish brown (2.5Y 5/2) mottles; some pebbles; massive with some cleavage planes; firm; calcareous; calcium carbonate concretions; mildly alkaline.

The A1 horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2). Texture of the A1 horizon is typically loam but ranges to include light clay loam.

The A2 horizon ranges from dark grayish brown (10YR 4/2) to light brownish gray (10YR 6/2).

The B2 horizon ranges from dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/6). The texture ranges from light to heavy clay loam. The reaction of the solum ranges from medium to very strongly acid.

Lindley soils are associated on the landscape with Keswick and Weller soils. They have less clay in the subsoil than Keswick soils and have more sand than the loess-derived Weller soils.

65E—Lindley loam, 14 to 18 percent slopes. This moderately steep soil is on irregular side slopes in timbered areas. It occurs as narrow, irregular bands that form the sides of valleys. Areas extend downslope to the alluvial soils in the narrow drainageways or stream bottoms.

This soil has the profile described as representative of the series. The surface layer is typically dark grayish brown.

Included with this soil in mapping are small areas of adjacent soils and more severely eroded areas. Some severely eroded areas are identified by spot symbols on the soil map.

This soil is not suited to row crops because of the steep slope and the severe erosion hazard. At one time, much of the original timber was cleared, and some areas were cropped. Now, only a small acreage managed with adjacent better soils is cropped. Most of the acreage has been converted to pasture. Some areas now have a second growth of timber. Eroded areas have poor tilth, which makes establishment of new stands of grasses and legumes difficult. Tree growth is usually slow.

The surface layer absorbs water slowly. The rapid runoff creates a serious erosion hazard, and drainageways in side slopes are gullied easily. Organic-matter content is less than 1 percent. Capability unit VIe–3.

65F—Lindley loam, 18 to 25 percent slopes. This steep soil is on side slopes in the timbered areas along major streams and tributaries. It is commonly along the Grand River and its tributaries. A small acreage is along the Platte River. Areas generally extend down the hillside to the alluvial soils near or in the stream bottom. Where slope breaks are very sharp, some of the acreage is adjacent to the high, narrow ridges. Areas are small to large and are irregular in shape.

This soil has a thinner subsoil than the less sloping Lindley soils, and free lime or carbonates are closer to the surface.

Included with this soil in mapping are small areas of other Lindley soils. Also included are areas where the surface layer is very thin. These severely eroded areas are identified by spot symbols on the soil map.

Almost all the acreage is in timber. Most areas are used as pasture. They furnish little livestock feed unless they are renovated. Small, cleared areas are readily eroded, and the plant cover reverts to weeds or scrubby, second growth timber. Fewer gullies form than in the uncleared areas because of the tree cover. The organic-matter content is less than 1 percent.

Pastured areas of this soil generally are not productive. The soil is best suited to woodland and wildlife habitat. Tree growth is slow. Some areas in pasture would be more productive if they were renovated. Operating farm machinery is hazardous because of the steep slopes, gullies, and generally rough terrain. Capability unit VIIe-1.

Lineville Series

The Lineville series consists of soils that are moderately well drained in the upper part and somewhat poorly drained in the lower part. These moderately sloping soils are on narrow ridgetops. Lineville soils formed in loess over pedisediment, which overlies a highly weathered glacial till, under native vegetation of prairie grasses and trees. Slopes are 5 to 9 percent.

In a representative profile the surface layer is very dark brown silt loam about 7 inches thick. The subsurface layer is brown silt loam about 4 inches thick. The subsoil extends to a depth of 44 inches. It is brown silty clay loam in the upper part; brown, grayish brown, yellowish brown, and dark yellowish brown clay loam in the next part; and strong brown clay loam in the lower part.

Lineville soils have moderately slow to very slow permeability and a high available water capacity. The subsoil is low in available phosphorus and very low in available potassium. Unless limed, the surface layer is slightly acid.

The Lineville soils are used primarily for row crops, but they have severe limitations. The major limitations for row crops are the moderate slopes and the clayey subsoil.

Representative profile of Lineville silt loam, 5 to 9 percent slopes, 590 feet north and 20 feet west of the southeast corner of sec. 4, T. 71 N., R. 29 W. on a north-facing slope of 6 percent:

Ap—0 to 7 inches; very dark brown (10YR 2/2) silt loam; grayish brown (10YR 5/2) dry; weak fine subangular blocky structure parting to weak fine granular and thin platy; friable; slightly acid; abrupt smooth boundary.

A2—7 to 11 inches; brown (10YR 4/3) silt loam, light brownish gray (10YR 6/2) dry; weak very fine subangular blocky structure parting to weak thin platy; friable; some very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) peds and coatings; strongly acid; clear smooth boundary.

B1—11 to 17 inches; brown (10YR 4/3) light silty clay loam; few light gray (10YR 7/2) dry coatings and few very dark grayish brown (10YR 3/2) peds; moderate very fine subangular blocky structure; friable; strongly acid; clear smooth boundary.

IIB21—17 to 23 inches; brown (10YR 4/3) silty clay loam; few fine faint yellowish brown (10YR 5/4 and 5/6) mottles; many light gray (10YR 7/2) silt coatings; moderate fine subangular blocky structure; friable; many sand grains; few dark bodies; strongly acid; clear smooth boundary.

IIB22t—23 to 28 inches; brown (10YR 4/3) light clay loam; common medium faint dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/6), and grayish brown (10YR 5/2) mottles; many light gray (10YR 7/2) silt coatings; moderate medium subangular blocky structure; friable; hard when dry; few discontinuous clay films; many dark bodies; medium acid; gradual smooth boundary.

IIB23t—28 to 36 inches; mottled grayish brown (10YR 5/2), yellowish brown (10YR 5/6), and dark yellowish brown (10YR 4/4) light clay loam; light gray (10YR 7/2) dry sand and silt coatings on peds; moderate medium subangular blocky structure; firm, hard when dry; many dark bodies and increasing sand content with increasing depth; medium acid; gradual smooth boundary.

IIIB24t—36 to 44 inches; brown (7.5YR 4/4) heavy clay loam; few fine faint grayish brown (10YR 5/2), common fine distinct strong brown (7.5YR 5/6 and 5/8), and common fine distinct yellowish red (5YR 5/8) mottles; weak medium subangular blocky structure; firm; thin clay films; many sand grains and small pebbles; medium acid; gradual smooth boundary.

IIIB25t—44 to 50 inches; brown (7.5YR 4/4) clay loam; common fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; moderate fine subangular blocky structure; firm; few brown (10YR 4/3) clay films; many pebbles; slightly acid; gradual smooth boundary.

IIIB26t—50 to 58 inches; strong brown (7.5YR 5/6) clay loam; moderate fine subangular blocky structure; firm; thick discontinuous dark brown (7.5YR 4/2) clay films on vertical faces; few pebbles and rocks; slightly acid; gradual smooth boundary.

IIIB3t—58 to 72 inches; mottled strong brown (7.5YR 5/6) and yellowish brown (10YR 5/4) clay loam; moderate fine subangular blocky structure; dark brown (10YR 3/3) thick discontinuous clay films; black (N 2/0) coatings on faces of peds; neutral.

The Ap horizon ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2). Texture of Ap horizon is typically silt loam but ranges to include loam.

The A2 horizon ranges from dark grayish brown (10YR 4/2) and brown (10YR 4/3) to grayish brown (10YR 5/2). Texture of the A2 horizon ranges from silt loam to loam.

Texture of the IIB2t horizon ranges from heavy silty clay loam to loam.

The IIIB horizon ranges from brown (7.5YR 4/4) to strong brown (7.5YR 5/6). Texture ranges from heavy clay loam to clay.

Lineville soils are associated on the landscape with Armstrong and Pershing soils. They have less sand in the A horizon then Armstrong soils and have more sand in the B horizon than Pershing soils.

452C—Lineville silt loam, 5 to 9 percent slopes. This moderately sloping soil is on narrow ridgetops.

Included with this soil in mapping are some small areas of Armstrong, Ladoga, Pershing, Weller, Adair, and Clarinda soils. Also included are small, severely eroded areas that are identified by spot symbols on the soil map.

This Lineville soil is suited to crops, but it is severely limited by low fertility and the clayey subsoil. It produces average hay and pasture. It is not too sloping for tillage, but erosion is a hazard. The organic-matter content is 1 to 2 percent. Capability unit IIIe–5.

Macksburg Series

The Macksburg series consists of somewhat poorly drained soils. These nearly level and gently sloping soils are on divides and wide ridges in the uplands. The Macksburg soils formed in loess under native vegetation of prairie grasses. Slopes are 0 to 5 percent.

In a representative profile the surface layer is black to very dark grayish brown silty clay loam about 22 inches thick. The subsoil extends to a depth of 55 inches. It is dark grayish brown silty clay loam in the upper part and grayish brown silty clay loam in the lower part. The substratum is grayish brown silty clay loam with strong brown and yellowish brown mottles.

Macksburg soils have moderately slow permeability and a high available water capacity. The subsoil is low in available phosphorus and is medium in available potassium. Unless limed, the surface layer is generally slightly acid.

The Macksburg soils are used primarily for cultivated crops. The hazard of erosion is slight on the gently sloping soils.

Representative profile of Macksburg silty clay loam, 0 to 2 percent slopes, 770 feet east and 2,400 feet south of the northwest corner of sec. 27, T. 72 N., R. 30 W. northeast of buildings in an alfalfa field:

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam; weak medium subangular blocky structure parting to weak fine granular; friable; slightly acid; abrupt clear boundary.

A12—7 to 14 inches; black (10YR 2/1) silty clay loam; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

A3—14 to 22 inches; very dark grayish brown (10YR 3/2) silty clay loam; very dark gray (10YR 3/1) coatings on peds; moderate very fine subangular blocky structure and moderate fine granular structure; friable; medium acid; clear smooth boundary.

B1—22 to 28 inches; dark grayish brown (10YR 4/2) silty clay loam; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) coatings on peds; moderate very fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B21t—28 to 37 inches; dark grayish brown (10YR 4/2) heavy silty clay loam; weak medium prismatic structure parting to moderate fine subangular blocky; firm; few to common fine distinct yellowish brown (10YR 5/4) mottles; few fine black (10YR 2/1) bodies; thin discontinuous clay films; medium acid; gradual smooth boundary.

B22t—37 to 43 inches; grayish brown (2.5Y 5/2) heavy silty clay loam; weak medium prismatic structure parting to moderate medium subangular blocky; firm; common fine faint brown (10YR 4/3) and yellowish brown (10YR 5/4) mottles; common fine black (10YR 2/1) bodies; thin discontinuous clay films; slightly acid; gradual smooth boundary.

B3t—43 to 55 inches; grayish brown (2.5Y 5/2) silty clay loam; weak coarse prismatic structure parting to weak medium and coarse subangular blocky; friable; many fine faint yellowish brown (10YR 5/4 and 5/6) mottles; very thin discontinuous clay films; slightly acid; gradual smooth boundary.

C—55 to 67 inches; grayish brown (2.5Y 5/2) silty clay loam; massive; friable; many fine distinct strong brown (7.5YR 5/6) and common fine distinct yellowish brown (10YR 5/6) mottles; many fine soft bodies; slightly acid.

The Ap or A1 horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The A horizon ranges from neutral to medium acid. The B horizon is 24 to 48 inches thick.

Macksburg soils formed in parent material similar to that of Winterset and Sharpsburg soils. Macksburg soils have more clay in the B horizon than Sharpsburg soils and darker colors are deeper. In contrast with Winterset soils, they have less clay in the B horizon. They have two chroma colors in the upper B horizon; Winterset soils have only one.

368—Macksburg silty clay loam, 0 to 2 percent slopes. This nearly level soil is on divides between the major streams in the uplands. Areas vary in size but range to large and regular in shape. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of Winterset and Sharpsburg soils. Small poorly drained areas that are significant in size are identified by spot symbols on the soil map.

This Macksburg soil is well suited to row crops. The organic-matter content is 4 to 6 percent. Capability unit I–1.

368B—Macksburg silty clay loam, 2 to 5 percent slopes. This gently sloping soil is on ridgetops in the uplands. Areas vary from small to large in size.

Included with this soil in mapping are small areas of nearly level Macksburg soils and Sharpsburg soils.

This Macksburg soil is well suited to row crops.

Erosion is a slight hazard because of the gentle slopes. The organic-matter content is 4 to 6 percent. Capability unit IIe–1.

Mystic Series

The Mystic series consists of moderately well drained and somewhat poorly drained soils. These moderately sloping and strongly sloping soils are on high terraces along major streams. Mystic soils formed in water-sorted glacial sediment, deposited as alluvium during an earlier geologic period, under a native vegetation of grass and forest vegetation. Slopes are 5 to 14 percent.

In a representative profile the surface layer is very dark grayish brown, very friable silt loam about 7 inches thick. The subsurface layer is dark grayish brown, very friable loam about 5 inches thick. The subsoil extends to a depth of 54 inches. It is brown clay loam in the upper part; reddish brown and brown clay in the next part; and brown, light brown, and reddish brown clay loam in the lower part. The substratum is mottled brown, light brown, and reddish brown, friable sandy clay loam.

Mystic soils have slow permeability and a moderate available water capacity. The subsoil is very low in available phosphorus and potassium. Unless limed, the surface layer is medium acid.

The Mystic soils are used primarily for hay and pasture. They are seasonally wet and seepy. Erosion and seasonal wetness are the major limitations for crops, hay, and pasture.

Representative profile of Mystic silt loam, 5 to 9 percent slopes, moderately eroded, 3,680 feet north and 320 feet west of southeast corner of sec. 34, T. 71 N., R. 28 W. on a 6 percent east-facing slope in an uneroded area:

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) dry; granular to thin platy structure; very friable; medium acid; clear smooth boundary.

A2—7 to 12 inches; dark grayish brown (10YR 4/2) loam; grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) dry; thin to very thin platy structure; very friable; strongly acid; clear smooth boundary.

B1t—12 to 16 inches; brown (10YR 4/3) light clay loam; fine and very fine subangular blocky structure; friable; few light gray silt coatings; strongly acid; gradual smooth boundary.

B21t—16 to 21 inches; brown (7.5YR 4/4) clay loam; fine subangular blocky structure; firm; few light gray (10YR 7/2) silt coatings and mottles; very strongly acid; gradual smooth boundary.

B22t—21 to 27 inches; reddish brown (5YR 4/4) light clay; few fine faint yellowish red (5YR 4/6) mottles and few fine distinct light gray (10YR 7/2) mottles; strong fine blocky structure; firm; thin clay films; very strongly acid; clear smooth boundary.

B23t—27 to 33 inches; brown (7.5YR 4/4) light clay; common fine distinct yellowish red (5YR 4/8) and grayish brown (10YR 5/2) mottles; brown (10YR 5/3) clay films and ped coats; moderate medium and fine angular blocky structure; firm; very strongly acid; clear smooth boundary.

B31—33 to 47 inches; brown (7.5YR 4/4) medium clay loam; few fine distinct yellowish red (5YR 4/6 and 4/8) and dark reddish gray (5YR 4/2) mottles; massive parting to weak medium angular blocky structure; firm; very strongly acid; gradual smooth boundary.

B32—47 to 54 inches; mottled brown (7.5YR 5/4), light brown (7.5YR 6/4), and reddish brown (5YR 4/4) clay loam; massive; friable; strongly acid; gradual smooth boundary.

C—54 to 62 inches; mottled brown (7.5YR 5/4), light brown (7.5YR 6/4), and reddish brown (5YR 4/4) sandy clay loam; massive; friable; strongly acid.

The Ap horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). It is dominantly silt loam, but ranges to light clay loam.

The A2 horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3) and from silt loam to loam.

The C horizon ranges from sandy loam to sandy clay loam.

Mystic soils are associated on the landscape with Caleb, Gara, Armstrong, and Pershing soils. They formed in parent material similar to that of Caleb soils. They have more clay in the B horizon than Caleb, Gara, and Pershing soils. Mystic soils have more sand in the C horizon than Armstrong soils.

592C2—Mystic silt loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on high terraces near major streams. It occurs as long and narrow to short and wide areas. It has a profile similar to the one described as representative of the series, but this soil is eroded and the surface layer is thinner. Included in mapping are small areas of Caleb, Pershing, and Gara soils.

This Mystic soil is better suited to hay and pasture than to row crops. Erosion control is needed if row crops are grown. The organic-matter content is 1 to 2 percent. Capability unit IIIe–4.

592D2—Mystic silt loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on high terraces near major streams. It occurs as long and narrow to short and wide areas. The profile is similar to the one described as representative of the series, but the dark surface layer is thinner. Included in mapping are small areas of Caleb, Pershing, and Gara soils.

This Mystic soil is better suited to hay and pasture than to row crops. It is susceptible to erosion. The organic-matter content is 1 to 2 percent. Capability unit IVe–4.

94D2—Mystic-Caleb complex, 9 to 14 percent slopes, moderately eroded. This strongly sloping map unit is on short side slopes of benches near the major streams and tributaries. It is 55 percent Mystic soil and 30 percent Caleb soil. Included in mapping are small areas of Ladoga, Pershing, Armstrong, and Gara soils and small sandy areas.

If well managed, this map unit is suited to row crops. If used for row crops, it is susceptible to erosion. It is usually managed with other soils as cropland or pasture. Gullies form readily in some waterways. The organic-matter content is 1 to 2 percent. Capability unit IVe-4.

Nira Series

The Nira series consists of moderately well drained soils. These moderately sloping soils are on upper side slopes and narrow ridgetops of the uplands. Nira soils formed in loess under native vegetation of prairie grasses. Slopes are 5 to 9 percent.

In a representative profile the surface layer is black and very dark gray silty clay loam about 13 inches thick. The subsoil extends to a depth of 44 inches. It is brown silty clay loam in the upper part and grayish brown silty clay loam in the lower part. The substratum is grayish brown silty clay loam mottled with brown.

Nira soils have moderately slow permeability and a high available water capacity. The subsoil is very low in available phosphorus and available potassium. Unless limed, the surface layer is generally slightly acid.

The Nira soils are used primarily for crops. The major hazard is erosion. Erosion control is needed.

Representative profile of Nira silty clay loam in an area of Nira-Sharpsburg silty clay loams, 5 to 9 percent slopes, about 2,140 feet west, 1,490 feet south of northeast corner of sec. 23, T. 73 N., R. 31 W. just west of the park road:

A1—0 to 8 inches; black (10YR 2/1) silty clay loam; moderate fine and very fine subangular blocky structure parting to weak fine subangular blocky; friable; slightly acid; clear smooth boundary.

A3—8 to 13 inches; very dark gray (10YR 3/1) silty clay loam; weak fine and very fine subangular blocky structure; friable; few brown (10YR 4/3) peds in lower part of horizon; medium acid; clear smooth boundary.

B1—13 to 19 inches; brown (10YR 4/3) silty clay loam; common very dark gray (10YR 3/1) coats on faces of peds; moderate fine subangular blocky structure; friable; few fine faint dark yellowish brown (10YR 4/4) mottles; medium acid; clear smooth boundary.

B21t—19 to 25 inches; brown (10YR 4/3) silty clay loam; some grayish brown (2.5Y 5/2) peds; moderate fine subangular blocky structure; friable; few thin discontinuous clay films; few fine dark bodies; medium acid; clear smooth boundary.

B22t—25 to 30 inches; grayish brown (2.5Y 5/2) silty clay loam; brown (10YR 4/3) coatings on peds; weak medium prismatic structure parting to moderate medium subangular blocky; friable; few fine dark bodies; thin discontinuous clay films; medium acid; gradual smooth boundary.

B3t—30 to 44 inches; grayish brown (2.5Y 5/2) silty clay loam; weak medium prismatic to moderate coarse subangular blocky structure; friable; common medium distinct brown (7.5YR 4/4) and strong brown (7.5YR 5/6) mottles; few dark bodies; thin discontinuous clay films; medium acid; gradual smooth boundary.

C—44 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam; massive; friable; common medium distinct brown (7.5YR 4/4) mottles; medium acid.

The A1 horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The A horizon ranges from neutral to medium acid.

Eroded units of Nira-Sharpsburg silty clay loams are outside the range defined for their respective series because they lack a mollic epipedon.

Nira soils formed in parent material similar to that of Sharpsburg and Clearfield soils. They have grayer colors in the lower part of the B horizon than Sharpsburg soils. The lower part of the solum formed in gray loess instead of the gray paleosol typical of Clearfield soils.

371C—Nira-Sharpsburg silty clay loams, 5 to 9 percent slopes. This moderately sloping map unit is on short, convex to straight side slopes surrounding the nearly level, stable upland divides. It is 60 percent Nira soil and 35 percent Sharpsburg soil. Areas are large in size and irregular in shape. The Nira soil has the profile described as representative of the series. The plow layer is 3 to 4 percent organic matter.

Included with this unit in mapping are small areas of Clearfield soils. Also included are some areas of gray clay, glacial till, reddish clay, sandy areas, and wet spots. These areas are identified by spot symbols on the soil map.

This unit is well suited to crops. It is susceptible to erosion. Erosion control is needed. Capability unit IIIe-2.

371C2—Nira-Sharpsburg silty clay loams, 5 to 9 percent slopes, moderately eroded. This moderately sloping map unit is on short, convex to straight side slopes surrounding nearly level, stable upland divides. It is 60 percent Nira soils and 35 percent Sharpsburg soils. Areas are large in size and irregular in shape. The surface layer is very dark grayish brown silty clay loam 7 inches thick. It is 2 to 3 percent organic matter. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The present plow layer rests directly above the firm subsoil. The subsoil may be exposed at the surface at the shoulder of slopes or near drains in sidehills. Included in mapping are small areas of Clearfield soils.

This map unit is moderately suited to row crops and well suited to hay and pasture. Most areas are used for those purposes. The soils become cloddy when tilled. They are more erodible than the uneroded soils because they are in poorer physical condition. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required. Erosion from runoff is the main hazard. Capability unit IIIe-2.

Nodaway Series

The Nodaway series consists of stratified and moderately well drained soils. These nearly level soils are on first bottoms along rivers and streams. Nodaway soils formed in silty alluvium under a native vegetation of prairie grasses and trees. Slopes are 0 to 2 percent.

In a representative profile the soil is stratified very dark gray and grayish brown silt loam about 80 inches thick. It has medium platy structure and some coarse sand strata below a depth of 70 inches.

Nodaway soils have moderate permeability and a high available water capacity. The subsoil is medium in available phosphorus and available potassium. Unless limed, the surface layer is slightly acid to neutral.

The Nodaway soils are used primarily for row crops. The major limitation is wetness from stream overflow.

Representative profile of Nodaway silt loam, 0 to 2 percent slopes, 2,450 feet north and 30 feet west of the southeast corner of sec. 24, T. 73 N., R. 29 W. on nearly level bottom land:

C—0 to 80 inches; stratified very dark gray (10YR 3/1) and grayish brown (10YR 5/2) silt loam; light gray (10YR 7/1) when dry; few fine distinct brown (7.5YR 4/4) mottles that increase with depth; medium platy structure; friable; common thin light brownish gray (10YR 6/2) and pale brown (10YR 6/3) sand strata; coarse sand strata at a depth of 70 inches and calcareous sand at a depth of 78 inches; yellowish brown (10YR 5/4) silt and sand strata below 63 inches; slightly acid to neutral.

The C horizon ranges from stratified, very dark gray (10YR 3/1) to light gray (10YR 7/2).

Nodaway soils are associated on the landscape with Colo and Coppock soils. They formed in parent material similar to that of Kennebec soils. They are lighter colored than Colo and Kennebec soils. Nodaway soils are less clayey than Coppock and Colo soils.

220—Nodaway silt loam, 0 to 2 percent slopes. This nearly level soil is on first bottoms near major streams and tributaries. It occurs as large to small areas near the stream channels. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of Kennebec, Coppock, and Colo soils. Also included are small sandy areas, which are identified by spot symbols on the soil map.

This Nodaway soil is well suited to row crops, but some small areas are managed as pasture or woodland with adjacent soils. Flooding is a hazard. The organic-matter content is less than 1 percent. Capability unit IIw–3.

C220—Nodaway silt loam, 0 to 2 percent slopes, channeled. This nearly level soil is on first bottoms with many old stream channels. It occurs as long, narrow, and irregularly shaped areas that are cut by old channels of meandering streams. In many places the oxbow channels are filled with water.

Included with this soil in mapping are soils in old streambeds, which vary from sand to clay in texture, and some areas of Colo and Wabash soils.

This Nodaway soil is usually in pasture or is left idle. It is susceptible to flooding. The organic-matter content is less than 1 percent. Capability unit Vw–1.

13B—Nodaway-Vesser silt loams, 2 to 5 percent slopes. This map unit is in narrow upland drainageways. It is 60 percent Nodaway soil and 30 percent Vesser soil. Areas are long and narrow.

Along narrow drainageways, the Nodaway soil is adjacent to the streams and the Vesser soil is at the base of the upland slopes. Some areas are dissected by gullies and cannot be crossed by machinery. This map unit commonly occurs in areas where the side slope soils formed under trees.

Most areas are managed along with the adjacent soils as pasture, woodland, or row crops. They can be used for intensive rowcropping if runoff from steeper soils is controlled and drainage is provided. The organic-matter content is less than 1 percent to 4 percent. Capability unit IIw–3.

Olmitz Series

The soils of the Olmitz series formed in loamy alluvial material washed off the adjacent slopes. These moderately well drained to well drained, gently sloping soils are on narrow foot slopes of 2 to 5 percent, below the steeper glacial till soils upslope and above the more level alluvial soils. They also occur on alluvial fan positions at the mouth of drainageways. They are near streams and tributaries in all parts of the county but are most common along the major streams. The native vegetation was prairie grasses.

The surface layer is black and dark brown, friable loam and light clay loam about 33 inches thick. It grades to very dark grayish brown in the lower part. The subsoil is dark brown, friable light clay loam.

Olmitz soils are moderately to moderately slowly permeable and have a high available water capacity. They absorb water readily, but they carry excessive runoff from the steeper side slopes. They have a deep, favorable root zone. Unless limed, the surface layer is typically medium acid. These soils are moderately fertile and easy to cultivate. The subsoil is low in available phosphorus and medium in available potassium.

Olmitz soils are subject to erosion. Although water is absorbed rapidly, the runoff from the adjacent slopes washes away some of the finer soil particles. Some deposition occurs on the gentle slopes.

These soils are suited to crops. They dry out readily, even after heavy rains, and in most places are in excellent tilth.

Representative profile of Olmitz loam, 2 to 5 percent slopes, 1,330 feet south and 260 feet west of the northeast corner of sec. 2, T. 71 N., R. 29 W. on gently sloping alluvium:

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

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

A13—16 to 24 inches; dark brown (10YR 2/2) light clay loam; very dark grayish brown (10YR 3/2) when kneaded; moderate very fine and fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A3—24 to 33 inches; very dark grayish brown (10YR 3/2) light clay loam; very dark grayish brown (10YR 3/2) when kneaded; moderate fine and medium subangular blocky structure; friable; concentration of small pebbles at a depth of 27 inches; neutral; gradual smooth boundary.

B1—33 to 46 inches; dark brown (10YR 3/3) light clay loam that is the same color when kneaded; moderate coarse prismatic structure parting to weak fine subangular blocky; friable; very dark grayish brown (10YR 3/2) coats on peds; few pebbles; neutral; gradual smooth boundary.

B2—46 to 52 inches; dark brown (10YR 3/3) light clay loam; brown (10YR 4/3) when kneaded; moderate coarse prismatic structure parting to weak fine subangular blocky; friable; few pebbles; neutral; gradual smooth boundary.

B3—52 to 63 inches; dark brown (10YR 3/3) light clay loam; brown (10YR 4/3) when kneaded; coatings on peds are brown (10YR 4/3) and are grayish brown (10YR 5/2) when dry; moderate coarse prismatic structure; friable; neutral.

The Ap horizon ranges from black (10YR 2/1) to very dark brown (10YR 2/2). The texture of the Ap horizon is typically loam but ranges to include light clay loam.

The B horizon ranges from dark brown (10YR 3/3) to brown (10YR 4/3).

The Olmitz soils are similar to the Colo soils but contain less clay and more sand than those soils.

273B—Olmitz loam, 2 to 5 percent slopes. This gently sloping soil is on fan-shaped alluvial deposits at the mouth of small hillside waterways and on narrow depositional foot slopes. The depositional areas typically lie adjacent to and between the steeper glacial side slopes and the more poorly drained, dark colored alluvial soils on first and second bottom lands. This soil occurs as small areas in all parts of the county along major streams and tributaries.

Included with this soil in mapping are small areas of gently sloping, more poorly drained alluvial soils near the lower border of the county.

This soil is suited to row crops if runoff and siltation are controlled. Most areas are small and are managed with adjacent soils as cropland or pasture. Erosion is a slight hazard because of rapid runoff from the adjacent, more sloping Shelby and Gara soils. Some depositions occur in the less sloping areas. Slowing runoff from the adjacent Shelby and Gara soils is the most effective way of controlling erosion. Most areas are in good tilth. The organic-matter content is 4 to 6 percent. Capability unit IIe-2.

Pershing Series

The Pershing series consists of moderately well drained to somewhat poorly drained soils. These gently to strongly sloping soils are on narrow ridgetops and convex side slopes of the uplands. They formed in loess under native vegetation of prairie 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 3 inches thick. The subsoil extends to a depth of 48 inches. It is brown silty clay loam in the upper part, mottled yellowish brown and grayish brown silty clay in the next part, and mottled yellowish brown and grayish brown silty clay loam in the lower part. The substratum is grayish brown silt loam with yellowish brown mottles.

The Pershing soils have slow permeability and a high available water capacity. The subsoil is high in available phosphorus and very low in available potassium. Unless limed, the surface layer is generally neutral or slightly acid.

The Pershing soils are used primarily for cultivated crops and pasture. Erosion is the major hazard for crops or pasture.

Representative profile of Pershing silt loam, 5 to 9 percent slopes, 1,910 feet east and 890 feet north of the southwest corner of sec. 18, T. 71 N., R. 28 W. on a 7 percent slope in a hayfield:

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

A2—7 to 10 inches; dark grayish brown (10YR 4/2) silt loam; light brownish gray (10YR 6/2) when dry; weak thin platy to moderate very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B1—10 to 14 inches; brown (10YR 4/3) silty clay loam; light brownish gray (10YR 6/2) when dry; moderate fine and very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21t—14 to 21 inches; grayish brown (10YR 5/2) silty clay loam; moderate fine and very fine subangular blocky structure; firm; few fine distinct yellowish brown (10YR 5/6), and few fine faint grayish brown (2.5Y 5/2) mottles; thin discontinuous clay films; common gray silt coatings on peds; medium acid; clear smooth boundary.

B22t—21 to 29 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) silty clay; strong fine and medium subangular blocky structure; firm; some dark gray (10YR 4/1) coatings on peds; thick continuous clay films; few black bodies; medium acid; gradual smooth boundary.

B23t—29 to 34 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) silty clay; weak fine prismatic structure parting to strong fine subangular blocky; firm; some dark gray (10YR 4/1) coatings on peds; few discontinuous clay films; common dark bodies; slightly acid; gradual smooth boundary.

B31t—34 to 41 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) silty clay loam; weak fine prismatic structure parting to strong fine subangular blocky; firm; some dark gray (10YR 4/1) coatings on peds; few discontinuous clay films; common dark bodies; slightly acid; gradual smooth boundary.

B32t—41 to 48 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) silty clay loam; weak fine prismatic structure; friable; thin discontinuous clay films on vertical cleavage faces; few dark bodies; slightly acid; gradual smooth boundary.

C—48 to 61 inches; grayish brown (2.5Y 5/2) silt loam; massive; friable; common fine distinct yellowish brown (10YR 5/6) mottles; few fine dark bodies; slightly acid.

The Ap horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2). It is slightly acid to neutral.

The A2 horizon ranges from dark grayish brown (10YR 4/2) to grayish brown (10YR 5/2). It is medium to slightly acid.

Pershing soils are associated on the landscape with Armstrong and Gara soils. They formed in parent material similar to that of Weller and Grundy soils. They have an A2 horizon, which the Grundy soils lack. They have a thinner A2 horizon than Weller soils. They have less sand in the solum than Armstrong and Gara soils.

131C—Pershing silt loam, 5 to 9 percent slopes. This moderately sloping soil is on narrow ridges and upper side slopes of the uplands. It occurs as long, narrow, and irregularly shaped areas. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of Weller and Armstrong soils. Small significant areas of other soils are identified by spot symbols on the soil map.

This Pershing soil is suited to cultivated crops and pasture. Because the soil areas are small, this soil is generally managed with other adjacent soils. It is susceptible to erosion. The organic-matter content is 2 to 4 percent. Capability unit IIIe–3.

131C2—Pershing silt loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on narrow ridgetops and upper side slopes in the uplands. It occurs as long, narrow, and irregularly shaped areas. This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner, about 5 inches thick.

Included with this soil in mapping are small areas of Weller and Armstrong soils. Small significant areas of other soils are identified by spot symbols on the soil map.

This Pershing soil is suited to cultivated crops and pasture. Because the soil areas are small, this soil is generally managed with other adjacent soils. It is susceptible to erosion. The organic-matter content is 1 to 2 percent. Capability unit IIIe–3.

131D—Pershing silt loam, 9 to 14 percent slopes. This strongly sloping soil is on side slopes of the uplands. It occurs as wide and irregularly shaped areas. Included in mapping are small areas of Gara soils.

This soil is better suited to pasture or hay crops than to row crops because of its strong slopes. It is susceptible to erosion. Erosion control is needed. The organic-matter content is 2 to 4 percent. Capability unit IVe–1.

T131B—Pershing silt loam, benches, 2 to 5 percent slopes. This gently sloping soil is on high, loess-covered terraces along some of the major streams in the county. Areas vary in size and shape. The profile of this soil is similar to the one described as representative of the series, but the underlying material is more variable.

The surface layer is very dark gray and is 6 to 10 inches thick. The silty clay subsoil is somewhat less mottled than in Pershing soils of the uplands. The underlying material, at a depth of 6 to 10 feet, is commonly stratified, dominantly sandy alluvial sediments. Some of the loess parent material may have come from adjacent stream valleys. Included in mapping are a few small areas of Weller soils.

Most of the acreage is cultivated. Erosion is a hazard in cultivated areas. If tilth is poor, the soil should be kept in meadow for a year.

This soil is seepy and has varied textures in deep cuts and fills. It has low potential for landfill and sewage lagoon sites because of the danger of ground water pollution. The organic-matter content is 2 to 4 percent. Capability unit IIIe–3.

T131C—Pershing silt loam, benches, 5 to 9 percent slopes. This moderately sloping soil is on high, loess-covered terraces along some of the major streams in the county. Areas vary in size and shape. The profile of this soil is similar to the one described as representative of the series, but the underlying material is more variable. The surface layer is very dark gray and is 6 to 10 inches thick. The silty clay subsoil is somewhat less mottled than the upland Pershing soils. The underlying material, at a depth of 6 to 8 feet, is mainly stratified, dominantly sandy alluvial sediments. Some of the loess parent material may have come from adjacent stream valleys. Included in mapping are a few small areas of Weller soils.

Most of the acreage is cultivated. Erosion is a hazard in cultivated areas. If tilth becomes poor, the soil should be kept in meadow for an additional year. Seepage and variable textures can be expected in deep cuts and fills. The soil has low potential for landfill and sewage lagoon sites because of the danger of ground water pollution. The organic-matter content is 2 to 4 percent. Capability unit IIIe–3.

Sharpsburg Series

The Sharpsburg series consists of moderately well drained soils. These gently sloping to strongly sloping soils are on divides and side slopes of the uplands. They formed in loess under native vegetation of prairie grasses. Slopes are 2 to 14 percent.

In a representative profile the surface layer is black, very dark brown, and very dark grayish brown silty clay loam about 13 inches thick. The subsoil extends to a depth of 50 inches. It is brown silty clay loam in the upper part, mottled brown and dark yellowish brown silty clay loam in the next part, and grayish brown and dark yellowish brown silty clay loam in the lower part. The substratum is mottled grayish brown and yellowish brown light silty clay loam.

Sharpsburg soils have moderately slow permeability and a high available water capacity. The subsoil is low in available phosphorus and medium in available potassium. Unless limed, the surface layer is generally slightly acid.

The Sharpsburg soils are used primarily for cultivated crops. The major hazard for crops is erosion on the sloping Sharpsburg soils. Erosion control is needed.

Representative profile of Sharpsburg silty clay loam, 2 to 5 percent slopes, 1,790 feet east, 160 feet south of the northwest corner of sec. 30, T. 73 N., R. 31 W. in a pasture on a west-facing ridge of 3 percent:

Ap—0 to 9 inches; black (10YR 2/1) and very dark brown (10YR 2/2) light silty clay loam; weak cloddy structure parting to weak fine granular; friable; slightly compacted at 0 to 3 inches; slightly acid; abrupt smooth boundary.

A3—9 to 13 inches; very dark grayish brown (10YR 3/2) silty clay loam; moderate fine subangular blocky structure; friable; few brown (10YR 4/3) peds; slightly acid; clear smooth boundary.

B21t—13 to 23 inches; brown (10YR 4/3) silty clay loam; dark yellowish brown (10YR 4/4) when kneaded; few very dark grayish brown (10YR 3/2) faces of peds in upper part of the horizon; weak medium prismatic structure parting to moderate fine and very fine subangular blocky; friable; thin discontinuous clay films; slightly acid; gradual smooth boundary.

B22t—23 to 31 inches; mottled brown (10YR 4/3) and dark yellowish brown (10YR 4/4) silty clay loam; weak medium prismatic structure parting to moderate fine subangular blocky; firm; common fine distinct grayish brown (2.5Y 5/2) and common fine faint brown (7.5YR 4/4) mottles; thin discontinuous clay films; few dark bodies; slightly acid; gradual smooth boundary.

B23t—31 to 40 inches; mottled dark yellowish brown (10YR 4/4) and grayish brown (2.5Y 5/2) silty clay loam; weak medium prismatic structure parting to weak medium and fine subangular blocky; firm; few fine faint brown (7.5YR 4/4) and few fine faint yellowish brown (10YR 5/6) mottles; few thin discontinuous clay films; common dark bodies; slightly acid; gradual smooth boundary.

B3t—40 to 50 inches; grayish brown (2.5Y 5/2) silty clay loam; massive, with some vertical cleavage; friable; common medium distinct yellowish brown (10YR 5/6) and brown (7.5YR 4/4) mottles; few thin discontinuous clay films on vertical cleavage faces; slightly acid; gradual smooth boundary.

C—50 to 62 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/4) light silty clay loam; massive; friable; common fine faint yellowish brown (10YR 5/6) and brown (7.5YR 4/4) mottles; few fine dark stains in bands; slightly acid.

The Ap or A1 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2).

The B2t horizon ranges from brown (10YR 4/3) to dark yellowish brown (10YR 4/4). Clay content of the B2t horizon ranges from 36 to 40 percent. It is medium to slightly acid. Texture of the C horizon ranges from light silty clay loam to heavy silt loam.

Eroded units of Sharpsburg soils are outside the range defined for the series because they lack a mollic epipedon. This difference, however, does not alter the use and management of the soils.

Sharpsburg soils formed in parent material similar to that of Macksburg and Nira soils. In contrast with Macksburg soils, they have less clay and a thinner dark colored surface layer. Gray mottles are deeper in Sharpsburg soils than in Nira soils.

370B—Sharpsburg silty clay loam, 2 to 5 percent slopes. This soil is on narrow gently sloping upland divides and on side slopes. Where ridges are narrow, it occupies the entire ridgetop. The profile of this soil is the one described as representative of the series.

Included with this soil in mapping are small areas of the gently sloping, more poorly drained Macksburg soils and very narrow areas of poorly drained alluvial soils along hillside waterways. If these areas are distinctly wet and up to about 2 acres in size, they are identified by wet spot symbols on the soil map. Significant areas of glacial till, gray clay, and reddish clay are also identified by spot symbols.

This soil is suited to row crops if erosion is controlled. Most of the acreage is in crops, but a small acreage is in pasture or farmsteads. Erosion is a slight hazard because of the gentle and in places long slopes. Waterways are wide and crossable by machinery. The organic-matter content is 3 to 4 percent. Capability unit IIe–1.

370C—Sharpsburg silty clay loam, 5 to 9 percent slopes. This moderately sloping soil is on narrow ridgetops and upper side slopes of high loess divides. Areas are irregular in size and shape. The plow layer contains 3 to 4 percent organic matter.

Included with this soil in mapping are small areas of poorly drained Clearfield soils near the lower boundary and around small, concave, bowl-like areas near upland waterways. Also included are small areas of more eroded and gently sloping Sharpsburg soils. Significant seepy areas or glacial till outcrops are identified by spot symbols on the soil map.

This soil is suited to row crops if erosion is controlled. It is generally managed with other soils. Erosion is a moderate hazard. Capability unit IIIe-2.

370C2—Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil occupies narrow divides and upper side slopes of broad upland divides. In most areas it is downslope from the Adair and Clarinda soils and the Adair-Shelby complex. This soil is adjacent to the Ladoga soil in areas where ridgetops extend toward major streams. Its profile is similar to the one described as representative of the Sharpsburg series, but the surface layer is very dark grayish brown silty clay loam, is 6 inches thick, and is 2 to 3 percent organic matter. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The plow layer rests directly on the firm subsoil.

Included with this soil in mapping are small areas of Nira soils and some small slightly or severely eroded areas. Significant areas of glacial till, gray clay, reddish clay, or sand are identified by spot symbols on the soil map.

This soil is suited to row crops if erosion is controlled. It tends to be cloddy when tilled. Because of poorer physical condition, it is more erodible than the uneroded soil. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required. The main hazard is erosion from runoff. Capability unit IIIe-2.

370D—Sharpsburg silty clay loam, 9 to 14 percent slopes. This strongly sloping soil is on the upper part of side slopes below narrow divides and forms part of the valley slopes.

Included with this soil in mapping are some small areas of Ladoga and Nira soils. Significant areas of glacial till, gray clay, and sand are identified by spot symbols on the soil map.

This Sharpsburg soil is suited to row crops if well managed. It is susceptible to erosion. Erosion control is needed in cultivated areas. The organic-matter content is 2 to 4 percent. Capability unit IIIe-2.

Shelby Series

The Shelby series consists of well drained to moderately well drained soils. These soils are moderately sloping on ridgetops and strongly sloping to steep on slopes of the uplands. The Shelby soils formed in glacial till under native vegetation of prairie grasses. Slopes are 5 to 25 percent.

In a representative profile the surface layer is black to very dark grayish brown light clay loam about 15 inches thick. The subsoil extends to a depth of 38 inches. It is dark brown, medium clay loam in the upper part; dark yellowish brown, medium to heavy clay loam in the next part; and brown light clay loam in the lower part. The substratum is mottled grayish brown and dark yellowish brown clay loam and is mildly alkaline.

Shelby soils have moderately slow permeability and a high available water capacity. The subsoil is low in available phosphorus and high in available potassium. Unless limed, the surface layer is generally medium acid.

The Shelby soils are used primarily for row crops and pasture. The major limitation is erosion.

Representative profile of Shelby clay loam, 9 to 14 percent slopes, 1,110 feet north and 80 feet east of the southwest corner of sec. 10, T. 72 N., R. 30 W.

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

A3—8 to 15 inches; very dark grayish brown (10YR 3/2) and some very dark brown (10YR 2/2) light clay loam; very fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21t—15 to 22 inches; dark brown (10YR 4/3) medium clay loam; very dark grayish brown (10YR 3/2) coating on peds; few fine distinct very dark gray (10YR 3/1) mottles; very fine and fine subangular blocky structure; friable; thin discontinuous clay films; medium acid; clear smooth boundary.

B22t—22 to 31 inches; dark yellowish brown (10YR 4/4) medium to heavy clay loam; few medium faint dark grayish brown (10YR 4/2) mottles; very dark gray (10YR 3/1) flows along root channels; strong fine subangular blocky structure; firm; few thin continuous clay films; few fine pebbles; slightly acid; clear smooth boundary.

B3t—31 to 38 inches; brown (10YR 4/3) light clay loam; very dark gray (10YR 3/1) along root channels; common fine distinct strong brown (7.5YR 5/6 and 5/8) and few fine faint grayish brown (10YR 5/2) mottles; weak medium and coarse subangular blocky structure; firm; few thin discontinuous clay films; neutral; abrupt smooth boundary.

C—38 to 65 inches; mottled grayish brown (2.5Y 5/2) and dark yellowish brown (10YR 4/4) heavy clay loam; few medium distinct strong brown (7.5YR 5/6 and 5/8) mottles; massive; some weak vertical cleavage; firm; thin discontinuous clay films decreasing with depth; few small stones and pebbles; common soft and hard carbonate nodules less than ¼-inch in diameter; mildly alkaline.

The Ap or A1 horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). Texture of the Ap horizon is typically light clay loam, but ranges to include loam.

The A3 horizon ranges from very dark grayish brown (10YR 3/2) to very dark brown (10YR 2/2) and from light clay loam to loam.

The B2t horizon ranges from dark brown (10YR 3/3) to dark yellowish brown (10YR 4/4).

Shelby soils are associated on the landscape with Sharpsburg and Lamoni soils. They formed in parent material similar to that of Gara and Lindley soils. They are more sandy than Sharpsburg soils and have less clay in the B2 horizon than Lamoni soils. They have a thicker A1 horizon than Gara and Lindley soils.

24C—Shelby clay loam, 5 to 9 percent slopes. This moderately sloping soil is on low ridges and side slopes. It occurs as narrow and irregularly shaped areas that are 2 to 10 acres in size. The plow layer contains 3 to 4 percent organic matter.

Included with this soil in mapping are small areas of Adair and Lamoni soils and small areas of Shelby soils with a thinner surface layer.

This Shelby soil is suited to row crops and pasture or hay. It is susceptible to erosion. Capability unit IIIe–5.

24C2—Shelby clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping soil is on low ridges and side slopes. It occurs as narrow and irregularly shaped areas that are 2 to 10 acres in size. Its profile is similar to the one described as representative of the series, but the surface layer is very dark grayish brown clay loam, is about 7 inches thick, and is 1 to 3 percent organic matter. A darker, thicker surface layer occurs near the base of slopes next to waterways. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The plow layer rests directly on the subsoil. The subsoil is exposed in places at the surface at the shoulders of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Adair and Lamoni soils and some small, severely and slightly eroded areas.

This soil is moderately suited to row crops and is well suited to hay and pasture. It becomes cloddy if tilled. Because of poorer physical condition, it is more erodible than the uneroded Shelby soil. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required.

The main hazard is further erosion from runoff. Removing the topsoil causes severe problems because of the unfavorable subsoil properties. Most areas are managed with adjacent soils. Capability unit IIIe–5.

24D—Shelby clay loam, 9 to 14 percent slopes. This strongly sloping soil is on side slopes directly downslope from Sharpsburg, Grundy, Adair, Clarinda, or Lamoni soils. It occurs as long, wide, and irregularly shaped areas. The profile of this soil is the one described as representative of the series. The plow layer contains 3 to 4 percent organic matter.

Included with this soil in mapping are small areas of Clarinda, Lamoni, and Adair soils. The more significant areas of Adair and Clarinda soils are identified by spot symbols on the soil map. A darker, thicker surface layer occurs near the base of some slopes or next to waterways.

This Shelby soil is suited to row crops. It is susceptible to erosion. Capability unit IIIe–5.

24D2—Shelby clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping soil is on side slopes directly downslope from Sharpsburg, Grundy, Adair, Clarinda, and Lamoni soils. It occurs as long, wide, and irregularly shaped areas. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown clay loam, is about 6 inches thick, and is 1 to 3 percent organic matter. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The present plow layer rests directly on the firm, dense subsoil. The subsoil is exposed in places at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Clarinda, Adair, and Lamoni soils. Many areas of Adair and Clarinda soils are identified by symbols on the soil map.

This Shelby soil is moderately suited to row crops and well suited to hay and pasture. Because of poorer physical condition, it is more erodible than the uneroded Shelby soil. It becomes cloddy if tilled. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required. Most of the acreage is used for hay and pasture.

The main hazard is further erosion from runoff. Removing the topsoil causes severe problems because of the unfavorable subsoil properties. Capability unit IIIe–5.

24D3—Shelby clay loam, 9 to 14 percent slopes, severely eroded. This strongly sloping soil is on side slopes. It occurs as small, wide and irregularly shaped areas. Its profile is similar to the one described as representative of the series, but the surface layer is dark brown or brown clay loam, about 6 inches thick, that is less than 1 percent organic matter. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The present plow layer rests directly on the firm, dense subsoil. The subsoil is exposed at the surface at the shoulder of slopes or near drains in sidehills. Included in mapping are small areas of Adair, Clarinda, and Lamoni soils.

This Shelby soil is suited to hay and pasture. It tends to be cloddy if tilled. Because of poorer physical condition, it is more erodible than the uneroded Shelby soil. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required.

The main hazard is further erosion. Most of the acreage is used for hay and pasture. Capability unit IVe–2.

24E—Shelby clay loam, 14 to 18 percent slopes. This moderately steep soil is on side slopes. It occurs as small and irregularly shaped areas. The plow layer contains 3 to 4 percent organic matter.

Included with this soil in mapping are small areas of Adair, Clarinda, and less sloping Shelby soils. Significant areas of the Adair and Clarinda soils are identified by spot symbols on the soil map.

This Shelby soil is better suited to small grain, hay, or permanent pasture than to row crops. It is susceptible to erosion. Capability unit IVe–2.

24E2—Shelby clay loam, 14 to 18 percent slopes, moderately eroded. This moderately steep soil is on side slopes. It occurs as small and irregularly shaped areas. It has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown clay loam, is about 6 inches thick, and is 1 to 3 percent organic matter. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The plow layer rests directly on the firm, dense subsoil.

The subsoil is exposed in places at the shoulder of slopes or near drains in sidehills.

Included with this soil in mapping are small areas of Adair, Clarinda, and less sloping Shelby soils. If they are of significant size, the Adair and Clarinda soils are identified by symbols on the soil map.

This Shelby soil is moderately suited to row crops and is well suited to hay and pasture crops. It becomes cloddy if tilled. Because of poorer physical condition, it is more erodible than the uneroded Shelby soil. Fertility is more limiting. Seedbed preparation is more difficult, and a higher level of management is required.

The main hazard is further erosion from runoff. Removing the topsoil causes severe problems because of the unfavorable subsoil properties. Most of the acreage is used for hay and pasture. Capability unit IVe–2.

24F2—Shelby clay loam, 18 to 25 percent slopes, moderately eroded. This steep soil is on side slopes. Areas are very irregular in size and shape. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark grayish brown clay loam, is about 6 inches thick, and is 1 to 3 percent organic matter. Erosion has removed part of the original surface layer, and plowing has mixed what is left with material from the subsoil. The plow layer rests directly on the firm, dense subsoil. The subsoil is exposed in places at the shoulder of slopes or near drains in the hillsides.

Included with this soil in mapping are small areas of Adair and Gara soils.

This Shelby soil is poorly suited to row crops. It is suited to hay and pasture. Most of the acreage is used for hay and pasture. The main hazard is further erosion. Because of poorer physical condition, this soil is more erodible than the uneroded Shelby soil. Removing the topsoil causes severe problems because of the unfavorable subsoil properties. Capability unit VIe–1.

Sperry Series

The Sperry series consists of very poorly drained soils. These soils are on broad, nearly level upland divides. The Sperry soils formed in loess under native vegetation of water-tolerant prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silt loam about 11 inches thick. The subsurface layer is dark gray silt loam about 9 inches thick. The subsoil extends to a depth of 51 inches. It is dark gray silty clay in the upper part, grayish brown silty clay loam in the next part, and olive gray silty clay loam in the lower part. The substratum is mottled grayish brown and light brownish gray silty clay loam.

Sperry soils have very slow permeability and a high available water capacity. The subsoil is very low in available phosphorus and available potassium. Unless limed, the surface layer is slightly acid.

The Sperry soils are used primarily for crops. They are managed with the adjacent Winterset and Macksburg soils. The major limitation is wetness.

Representative profile of Sperry silt loam, 0 to 2 percent slopes, 1,790 feet east and 450 feet north of the southwest corner of sec. 31, T. 73 N., R. 30 W., on a level divide:

Ap—0 to 11 inches; black (10YR 2/1) silt loam; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A2—11 to 20 inches; dark gray (10YR 4/1) silt loam; light gray (10YR 6/1) dry silt coats; weak fine subangular blocky structure parting to thin fine platy; friable; slightly acid; abrupt smooth boundary.

B21tg—20 to 28 inches; dark gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) coatings on peds, common fine distinct dark yellowish brown (10YR 4/4) mottles; strong fine subangular blocky structure; firm; continuous clay films; medium acid; clear smooth boundary.

B22tg—28 to 35 inches; dark gray (10YR 4/1) light silty clay; few very dark gray (10YR 3/1) coatings on peds, many fine and medium distinct yellowish brown (10YR 5/4 and 5/6) and dark yellowish brown (10YR 4/4) mottles; moderate fine and medium subangular blocky structure; firm; thick continuous clay films; slightly acid; gradual smooth boundary.

B23tg—35 to 43 inches; grayish brown (2.5Y 5/2) heavy silty clay loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) and few distinct dark yellowish brown (10YR 4/4) and faint dark gray (10YR 4/1) mottles; moderate medium subangular blocky structure; firm; thin discontinuous very dark gray (10YR 3/1) clay films; few fine dark bodies; neutral; clear smooth boundary.

B3tg—43 to 51 inches; olive gray (5Y 5/2) medium silty clay loam; few distinct strong brown (7.5YR 5/6 and 5/8) mottles; weak medium prismatic structure parting to medium subangular blocky; friable; thin discontinuous very dark gray (10YR 3/1) clay films in root channels and on faces of peds; few fine dark bodies; neutral; gradual smooth boundary.

C1g—51 to 63 inches; mottled grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) silty clay loam; common fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; massive parting to weak medium prismatic structure; friable; thin discontinuous clay films on vertical cleavage faces; dark organic-matter stains in root channels; neutral; gradual smooth boundary.

C2—63 to 72 inches; light brownish gray (2.5Y 6/2) silt loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; dark organic-matter stains in old root channels; neutral.

The Ap horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1).

Sperry soils are associated on the landscape with Winterset and Macksburg soils and formed in similar parent material. They have an A2 horizon that those soils lack.

122—Sperry silt loam, 0 to 2 percent slopes. This nearly level to depressional soil is on broad upland divides. It occurs as small and irregularly shaped areas.

Included with this soil in mapping are very small areas of adjacent Winterset and Macksburg soils. Where associated with Haig soils, it has a higher clay content in the subsoil.

This Sperry soil is suited to row crops. It is generally farmed with adjacent Winterset and Macksburg soils. It is susceptible to wetness. The organic-matter content is 2 to 4 percent. Capability unit IIIw–2.

Vesser Series

The Vesser series consists of somewhat poorly drained to poorly drained soils. These soils are nearly level on bottom land and gently sloping on foot slopes. They formed in alluvium. The native vegetation was forest and prairie grasses. Slopes are 0 to 5 percent.

In a representative profile the surface layer is about 10 inches thick and consists of very dark gray friable silt loam. The subsurface layer is 15 inches thick and consists of dark gray friable silt loam. Mottling begins at a depth of 14 inches and continues through the subsoil. Mottles are predominantly reddish brown. The subsoil, which extends to a depth of about 70 inches, is dark gray, and very dark gray, dominantly firm silty clay loam.

Vesser soils have moderate permeability and a high available water capacity. The subsoil is medium in available phosphorus and low in available potassium. Unless limed, the surface layer is slightly acid.

Vesser soils are used primarily for cultivated crops and pasture. The major limitation is wetness.

Representative profile of Vesser silt loam, 0 to 2 percent slopes, 2,160 feet north and 150 feet east of the southwest corner of sec. 12, R. 71 N., R. 28 W. on nearly level bottom land:

Ap—0 to 10 inches; very dark gray (10YR 3/1) silt loam; dark gray (10YR 4/1) dry; moderate fine subangular blocky structure parting to weak fine granular; friable; slightly acid; abrupt smooth boundary.

A21—10 to 14 inches; dark gray (10YR 4/1) silt loam; light gray (10YR 7/1) dry silt coatings; weak fine subangular blocky structure; friable; medium acid; clear smooth boundary.

A22—14 to 25 inches; dark gray (10YR 4/1) silt loam; light gray (10YR 6/1 and 7/1) dry silt coatings; few fine distinct reddish brown (2.5YR 4/4) mottles; few thin black (10YR 2/1) coatings on peds; weak medium platy and weak medium subangular blocky structure; friable; strongly acid; gradual smooth boundary.

B21t—25 to 33 inches; mixed very dark gray (10YR 3/1) and dark gray (10YR 4/1) silty clay loam; few fine distinct reddish brown (2.5YR 4/4) mottles; gray (10YR 5/1) silt coatings; moderate to fine medium prismatic structure; firm; thin discontinuous black (10YR 2/1) clay films; strongly acid; gradual smooth boundary.

B22t—33 to 45 inches; dark gray (10YR 4/1) silty clay loam; few fine distinct reddish brown (2.5YR 4/4), brown (7.5YR 4/4) and strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to moderate medium subangular blocky; common very dark gray (10YR 3/1) coatings on faces of peds; firm; medium acid; gradual smooth boundary.

B23t—45 to 70 inches; dark gray (10YR 4/1) silty clay loam; common fine faint brown (10YR 4/3), distinct dark yellowish brown (10YR 4/4) and distinct strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to weak and moderate medium subangular blocky; firm; medium acid.

The Ap horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1). The Ap horizon is typically silt loam but ranges to include light silty clay loam.

The A2 horizon ranges from dark gray (10YR 4/1) to very dark grayish brown (10YR 5/2) and is 12 to 20 inches thick.

The B2t horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 5/2).

Vesser soils are associated on the landscape with Nodaway, Colo, and Olmitz soils. Vesser soils have a thick, gray A2 horizon that Nodaway, Colo, and Olmitz soils lack. Vesser soils generally contain less clay in the subsoil than Humeston soils.

51—Vesser silt loam, 0 to 2 percent slopes. This nearly level soil is on low second bottoms. It has the profile described as representative of the series. Some areas, however, have slightly more clay in the subsoil and are less permeable and more poorly drained than this soil.

Included with this soil in mapping are small areas of adjacent and associated alluvial soils. Also included are small areas of Humeston soils.

Wetness is the only limitation. The soil is suited to crops if adequately drained. Most areas are in crops and are managed with adjacent soils. In low level areas, water stands for moderately long periods. It overflows only when floodwaters are very high. Tilth is generally good, except where water stands. The soil can be row cropped often if it is tilled and surface drained. The organic-matter content is 2 to 4 percent. Capability unit IIw–1.

Wabash Series

The Wabash series consists of very poorly drained soils. These nearly level soils are on stream bottom land. They formed in alluvium under a native vegetation of water-tolerant grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam about 17 inches thick and black silty clay to a depth of 40 inches. The subsoil, which extends to a depth of 50 inches, is very dark gray silty clay. The substratum is dark gray light silty clay that grades to gray in the lower part.

Wabash soils have very slow permeability and a moderate available water capacity. The subsoil is high in available phosphorus and medium in available subsoil potassium. Unless limed, the surface layer is slightly acid.

The Wabash soils are used primarily for cultivated crops and hay or pasture. The major hazard is wetness because of the slow permeability and occasional flooding.

Representative profile of Wabash silty clay loam, 0 to 2 percent slopes, 1,000 feet south and 370 feet west of the northeast corner of sec. 31, T. 71 N., R. 31 W. on a nearly level bottom land and in a pasture:

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam; moderate medium and very fine subangular blocky and fine granular structure; friable; slightly acid; clear smooth boundary.

A12—8 to 17 inches; black (10YR 2/1) silty clay loam; moderate very fine subangular blocky and fine granular structure; friable; slightly acid; gradual smooth boundary.

A13—17 to 28 inches; black (N 2/0) silty clay; moderate fine subangular blocky structure; firm; sheen on ped faces; neutral; gradual smooth boundary.

A3—28 to 40 inches; black (10YR 2/1) silty clay; moderate medium subangular blocky structure parting to fine subangular blocky; firm; sheen on faces of peds; neutral; gradual smooth boundary.

Bg—40 to 50 inches; very dark gray (10YR 3/1) silty clay; moderate medium subangular blocky structure; firm; sheen on faces of peds; neutral; gradual smooth boundary.

Cg—50 to 72 inches, dark gray (10YR 4/1) light silty clay; grading to gray (10YR 5/1) in the lower part; massive; firm; neutral.

The A horizon ranges from black (N 2/0) to very dark gray (10YR 3/1) and from silty clay loam to silty clay. It is neutral to medium acid.

The B horizon ranges from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2).

The C horizon ranges from dark gray (10YR 4/1) to light gray (10YR 6/1) and from slightly acid to neutral.

Wabash soils are associated on the landscape with Colo, Nodaway, Humeston, and Kennebec soils. Wabash soils are more clayey than Colo, Nodaway, and Kennebec soils. They lack the A2 horizon that Humeston soils have.

248—Wabash silty clay loam, 0 to 2 percent slopes. This nearly level soil is on low bottom lands that are sometimes flooded. It occurs as irregularly shaped areas that are from 5 to 50 acres in size.

Included with this soil in mapping are small areas of Humeston, Colo, and Wabash silty clay soils.

This Wabash soil is used for pasture and hay. If drained, it can be used for crops. It is susceptible to wetness, and artificial drainage is needed to remove excess water. The organic-matter content is 4 to 6 percent. Capability unit IIIw-3.

Weller Series

The Weller series consists of moderately well drained soils. These moderately sloping soils are on side slopes in the uplands. Weller soils formed in loess under a native vegetation of trees. Slopes are 5 to 9 percent.

In a representative profile the surface layer is very dark grayish brown silt loam about 4 inches thick. The subsurface layer is dark grayish brown silt loam about 8 inches thick. The subsoil extends to a depth of 63 inches. It is yellowish brown silty clay loam in the upper part; yellowish brown silty clay in the next part; and mottled grayish brown, light brownish gray, and yellowish brown silty clay loam in the lower part.

Weller soils have slow permeability and a high available water capacity. The subsoil is medium in available phosphorus and very low in available potassium. Unless limed, the surface layer is slightly acid.

Cleared areas are in row crops. The rest of the acreage is timber pasture. The major limitation is erosion.

Representative profile of Weller silt loam, 5 to 9 percent slopes, located 2,080 feet south and 2,640 feet east of northwest corner of sec. 34, T. 71 N., R. 28 W.

A1—0 to 4 inches; very dark grayish brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) dry; weak thin platy structure; very friable; slightly acid; clear smooth boundary.

A2—4 to 12 inches; dark grayish brown (10YR 4/2) and brown (10YR 5/3) silt loam; light brownish gray (10YR 6/2) and very pale brown (10YR 7/3) dry; moderate medium platy structure; very friable; medium acid; clear smooth boundary.

B1t—12 to 19 inches; yellowish brown (10YR 5/4) silty clay loam, grayish brown (10YR 5/2) coatings on peds; strong moderate subangular and angular blocky structure; firm; light gray (10YR 7/1) dry silt coatings on peds; very strongly acid; clear smooth boundary.

B21t—19 to 25 inches; yellowish brown (10YR 5/4) silty clay; strong fine subangular and angular blocky structure; firm; light gray (10YR 7/1) silt coatings; continuous clay films; very strongly acid; gradual smooth boundary.

B22t—25 to 31 inches; yellowish brown (10YR 5/4) silty clay; few fine grayish brown (2.5Y 5/2) mottles and brown (7.5YR 4/4) mottles; weak very fine subangular blocky structure; firm; common dark bodies; very strongly acid; gradual smooth boundary.

B31t—31 to 41 inches; mottled grayish brown (10YR 5/2) and yellowish brown (10YR 5/4) heavy silty clay loam; few fine distinct brown (7.5Y 4/4) mottles; weak medium and fine subangular blocky structure; firm; light gray (10YR 7/1) silt coatings; common dark bodies; strongly acid; gradual smooth boundary.

B32t—41 to 48 inches; mottled yellowish brown (10YR 5/4) and light brownish gray (10YR 6/2) medium silty clay loam; few fine distinct brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; firm; common dark bodies; medium acid; gradual smooth boundary.

B33—48 to 63 inches; mottled yellowish brown (10YR 5/4) and light brownish gray (10YR 6/2) light silty clay loam; few fine distinct brown (7.5YR 4/4) mottles; weak medium subangular blocky structure; friable; common dark bodies; medium acid.

The A1 horizon ranges from very dark gray (10YR 3/1) to grayish brown (10YR 4/2).

The B2t horizon ranges from dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/4). Because the Weller soils in Union County lack mottles with chroma of 2 or less within 10 inches below the top of the argillic horizon, they are outside the range defined for the series.

Weller soils are associated on the landscape with the Lindley and Keswick soils. They formed in parent material similar to that of Pershing and Grundy soils. They have a thicker A2 horizon than Pershing and Grundy soils. Weller soils have less sand throughout the profile than Lindley and Keswick soils.

132C—Weller silt loam, 5 to 9 percent slopes. This moderately sloping soil is on narrow ridges and upper side slopes. It occurs as long and narrow and irregularly shaped areas.

Included with this soil in mapping are small areas of less sloping Weller soils and small areas of eroded soils. Also included are small areas of Keswick and Lindley soils.

This Weller soil is suited to row crops but is susceptible to erosion in cleared and row cropped areas. Some areas are in timber. The organic-matter content is 1 to 2 percent. Capability unit IIIe–3.

Winterset Series

The Winterset series consists of poorly drained soils. These nearly level soils are on broad upland ridgetops. They formed in loess under native vegetation of prairie grasses. Slopes are 0 to 2 percent.

In a representative profile the surface layer is black silty clay loam about 18 inches thick. The subsoil extends to a depth of 52 inches. It is very dark gray heavy silty clay loam in the upper part; dark grayish brown heavy silt clay loam in the next part; and grayish brown silty clay loam in the lower part. The substratum is mottled grayish brown and light olive brown light silty clay loam.

Winterset soils have moderately slow to slow permeability and a high available water capacity. The available subsoil is low to medium in available phosphorus and medium in available potassium. Unless limed, the surface layer is slightly acid.

The Winterset soils are used primarily for row crops. The major limitation is wetness.

Representative profile of Winterset silty clay loam, 0 to 2 percent slopes, 100 feet north and 1,620 feet east of the southwest corner of sec. 31, T. 73 N., R. 30 W. on a level upland divide:

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

A12—8 to 18 inches; black (10YR 2/1) silty clay loam; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B21—18 to 26 inches; very dark gray (10YR 3/1) heavy silty clay loam; common fine faint dark grayish brown (10YR 4/2) and few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; moderate fine subangular blocky structure parting to very fine subangular blocky; friable to firm; slightly acid; clear smooth boundary.

B22tg—26 to 33 inches; dark grayish brown (10YR 4/2) heavy silty clay loam; few dark gray (10YR 4/1) coatings on peds; weak medium prismatic structure parting to moderate fine subangular blocky; firm; thin discontinuous clay films; common fine dark oxides; slightly acid; gradual smooth boundary.

B23tg—33 to 42 inches; grayish brown (2.5Y 5/2) silty clay loam; common fine distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6 and 5/8) mottles; moderate medium prismatic structure parting to moderate fine subangular blocky; firm; thin discontinuous very dark gray clay films on faces of peds; slightly acid; gradual smooth boundary.

B3tg—42 to 52 inches; grayish brown (2.5Y 5/2) silty clay loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; moderate medium prismatic structure parting to moderate fine subangular blocky; friable; slightly acid; gradual smooth boundary.

C1g—52 to 61 inches; mottled grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) light silty clay loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; thin discontinuous clay films on vertical cleavage faces; dark organic-matter stains in old root channels; slightly acid; gradual smooth boundary.

C2—61 to 75 inches; mottled grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/6) light silty clay loam; massive; friable; few fine dark bodies; neutral.

The B horizon ranges from very dark gray (10YR 3/1) to light brownish gray (2.5Y 6/2). The clay content of the B horizon ranges from 36 to 42 percent.

Texture of the C horizon ranges from silty clay loam to silt loam.

Winterset soils are associated on the landscape with Macksburg and Sperry soils and formed in similar parent material. Winterset soils have more clay in the B2 horizon than Macksburg soils. In contrast with Sperry soils, they have a thicker dark A1 horizon and lack an A2 horizon.

369—Winterset silty clay loam, 0 to 2 percent slopes. This nearly level soil is on broad upland ridgetops. It occurs as broad and irregularly shaped areas.

Included with this soil in mapping are small areas of Macksburg and Sperry soils. Some small areas of Sperry soils are identified by spot symbols on the soil map.

This Winterset soil is well suited to row crops. It is susceptible to wetness. The organic-matter content is 4 to 6 percent. Capability unit IIw-2.

Use and Management of the Soils

The soil survey is a detailed inventory and evaluation of the most basic resource of the survey area—the soil. It is useful in adjusting land use, including urbanization, to the limitations and potentials of natural resources and environment. Also, it can 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 about the nature of the soils and about unique aspects of behavior of the soils. These notes include data on erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic tank disposal systems, and other factors affecting the productivity, potential, and limitations of the soils under various uses and management. In this way, field experience and measured data on soil properties and performance are used as a basis for predicting soil behavior.

Information in this section is useful in planning use and management of soils for crops and pasture, rangeland, and woodland, as sites for buildings, highways and other transportation systems, sanitary facilities, and parks and other recreation facilities, and for wildlife habitat. From the data presented, the potential of each soil for specified land uses can be determined, soil limitations to these land uses can be identified, and costly failures in houses and other structures, caused by unfavorable soil properties, can be avoided. A site where soil properties are favorable can be selected, or practices that will overcome the soil limitations can be planned.

Planners and others using the soil system can evaluate the impact of specific land uses on the overall productivity of the survey area or other broad planning area and on the environment. Productivity and the environment are closely related to the nature of the soil. Plans should maintain or create a land-use pattern in harmony with the natural soil.

Contractors can find information that is useful in locating sources of sand and gravel, roadfill, and topsoil. Other information indicates the presence of bedrock, wetness, or very firm soil horizons that cause difficulty in excavation.

Health officials, highway officials, engineers, and many other specialists also can find useful information in this soil survey. The safe disposal of wastes, for example, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, and trees and shrubs are influenced by the nature of the soil.

Crops and Pasture

About 110,269 acres in Union County is used for crops. About 115,000 acres is used for pasture. Much of the approximately 22,000 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 and sorghums occupy a smaller acreage.

Many pastures in the county are in permanent bluegrass. Some have been renovated, and other pasture species have been introduced, for example, grasses and legumes, such as bromegrass, orchardgrass, birdsfoot trefoil, and other pasture plants.

Many soils in the county are subject to erosion. The erosion hazard is most severe on the Adair, Caleb, Gara, Grundy, Ladoga, Lamoni, Pershing, Sharpsburg, and Shelby soils. These soils erode easily because runoff is rapid on the steeper slopes. The moderately sloping Clarinda and Nira soils are also susceptible to erosion. Gullying is a serious hazard on the Adair, Caleb, Gara, and Shelby soils, particularly on the steeper slopes. If gullying is not controlled, the gullies rapidly work their way upslope.

Graded and tile outlet terraces are commonly used to control erosion. Tilling on the contour is also a common erosion control practice. Grade stabilization structures, farm ponds, and grassed waterways are used to control gullying. Farm ponds also provide water for livestock and recreation.

Wetness is a limitation on some of the bottom land soils. Colo soils, the Colo-Ely silty clay loams, and Humeston, Vesser, and Wabash soils are subject to excess wetness because of a high water table or runoff from adjacent uplands, or both. Wetness is a particular problem on these soils because of the moderately slowly or slowly permeable subsoil.

Diversion terraces divert runoff from bottom land soils. Tile drainage and surface drains also are used to remove excess water from the bottom land soils.

Flooding is a hazard on some of the bottom land in periods of high rainfall.

Capability grouping

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops, or other crops having special requirements.

The soils are classified according to degree and kinds of permanent limitations but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils and without consideration of possible major reclamation.

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

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

CAPABILITY CLASSES, the broadest grouping, 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 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 or range, woodland, or wildlife food and cover.
- Class VI soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.
- Class VII soils have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to pasture, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (None in Union County.)

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 the main limitation is risk of erosion unless close plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils, the wetness can be partly corrected by artificial drainage) ; *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in Union County, shows that the chief limitation is climate that is too cold or too dry.

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

CAPABILITY UNITS are soil groups within 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, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

The names of soil series represented in a capability unit are named in the description of the capability unit, but this does not mean that all the soils of a given series appear in the unit. To find the names of all the soils in any given capability unit, refer to the "Guide to Map Units" at the back of this survey.

In the following pages the capability units in Union County are described, and use and management of the soils is suggested.

CAPABILITY UNIT I–1

The one soil in this unit, Macksburg silty clay loam, 0 to 2 percent slopes, is a nearly level, somewhat poorly drained soil on uplands.

This soil has a friable silty clay loam surface layer and a firm to friable silty clay loam subsoil. It has a high available water capacity and is moderately slowly permeable. It absorbs much of the rain that falls, and it holds much of this moisture available for plants. It has properties favorable for good root development.

The organic-matter content is high. Unless limed, the surface layer is slightly acid. The subsoil is low in available phosphorus and medium in available potassium.

This soil warms up quickly in spring and can be worked soon after a rain. It is easy to keep in good tilth. It is not subject to significant erosion. Surface drainage is adequate even though the soil is nearly level.

Nearly all the acreage is used for row crops. Small areas are usually farmed with more sloping or somewhat poorly drained acreages of adjacent soils. Corn, soybeans, small grain, hay, and pasture grasses are grown. Corn and soybeans are the major crops.

This soil is suited to row crops year after year if fertility and tilth are maintained and weeds and insects are controlled. An occasional year of meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects are problems.

CAPABILITY UNIT I–2

The one soil in this unit, Kennebec silt loam, 0 to 2 percent slopes, is a nearly level, moderately well drained soil of the bottom land and benches.

This soil has a silt loam surface layer and substratum. It has a high available water capacity and is moderately permeable. It absorbs all rainfall when rain falls in normal amounts and holds most of it available for plants. It can usually be tilled earlier in spring than the wetter associated soils.

This soil is slightly acid. The organic-matter content is high. The subsoil is low in available phosphorus and very low to low in available potassium.

Flooding can occur during periods of high rainfall or in spring during snowmelt. Most flooding occurs in spring before crops are planted. The slope is enough to prevent ponding, and there is no hazard of erosion.

Most of the acreage is used for cultivated crops. Some areas are pasture or woodland. Some are large enough to be farmed separately, but most are managed along with adjacent soils. Corn, soybeans, grain sorghum, small grain, and hay are grown. Corn and soybeans are the main crops.

These soils are suited to row crops year after year if fertility and tilth are maintained and weeds and insects are controlled. An occasional meadow or green manure crop can be grown if tilth becomes poor or weeds or insects are problems. Some areas may need lime. All areas need additions of fertilizer if high yields are to be obtained under a cropping system that is mostly row crops.

Some areas need protection from overflow. Old bayous can be filled and stream channels straightened to reduce flooding. Diversion terraces protect areas at the base of slopes from runoff.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping Ladoga, Macksburg, and Sharpsburg soils of the uplands and benches. Macksburg soils are somewhat poorly drained. Ladoga and Sharpsburg soils are moderately well drained.

These soils have a friable surface layer of silt loam and silty clay loam. The subsoil is friable or firm, moderately slowly permeable silty clay loam. The soils absorb most of the rain that falls and have properties favorable for good root development.

These soils have a high available water capacity. The organic-matter content is moderate to high. Unless limed, these soils are slightly acid to medium acid. The subsoil is low to medium in available phosphorus and very low to medium in available potassium.

These soils are well suited to row crops but are subject to sheet erosion because of the slope. They dry quickly in spring and after a rain. They are easy to keep in good tilth.

Many areas are large enough to be farmed separately but are irregular in shape. They are normally managed with small areas of nearly level or moderately sloping acreages of adjacent soils. Nearly all the acreage is used for cultivated crops. Corn and soybeans are the main crops. Part of the acreage is in small grain or in hay and pasture.

Runoff is medium. Erosion control is needed for maximum yields and intensive production of row crops. If terraced, these soils can be safely used for row crops year after year. An occasional year of meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects become problems.

Some areas of these soils are difficult to terrace because of irregular slopes. A system of tile outlet terraces may be needed to protect these soils from erosion. Contour tillage and less intensive use of row crops may be more practical. Soils in this group usually stay in good tilth if crop residue is returned to the soil.

CAPABILITY UNIT IIe-2

This unit consists of gently sloping, well drained to moderately well drained Judson and Olmitz soils on low foot slopes or alluvial fans.

These soils have a very thick, friable loam and silty clay loam surface layer and a friable to firm clay loam to silty clay loam subsoil. Permeability is moderate to moderately slow in most places, and available water capacity is high. These soils absorb much of the rainfall. They have properties favorable for good root development.

The organic-matter content is high. Unless limed, the surface layer ranges from medium to slightly acid. The subsoil is low in available phosphorus and medium to low in available potassium.

These soils are well suited to row crops and other crops commonly grown in the county. They warm up easily in spring and dry out quickly after a rain. Tilth is generally good.

Erosion is a slight problem. These soils receive some deposition from the steeper soils upslope. These deposits are less fertile and lower in organic matter than the original topsoil. A new seeding may occasionally be lost because of these deposits. Wetness is not a problem in most places because of the slope, but some small areas bordering poorly drained soils need tile.

Areas of these soils are generally small. When they are managed with the steeper, adjacent soils upslope they are used for hay or pasture. Other areas are intensively row cropped with more poorly drained alluvial soils downslope.

Diversion terraces are used to intercept runoff from steeper soils upslope and to reduce the deposition. Farming on the contour reduces runoff and the hazard of erosion. If these practices are used, row crops can be safely grown year after year. An occasional meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects are problems. Tilth is generally easy to maintain if crop residue is returned to the soil.

CAPABILITY UNIT IIe-3

The one soil in this unit, Grundy silty clay loam, 2 to 5 percent slopes, is a gently sloping, somewhat poorly drained soil on uplands.

This soil has a friable light silty clay loam surface layer and a firm to friable light silty clay subsoil that is slowly permeable. Runoff is medium. The subsoil has a high available water capacity. This soil has properties favorable to good root development.

The organic-matter content is moderate. Unless limed, the surface layer is slightly acid. The subsoil is very low to low in available phosphorus and low to medium in available potassium.

This soil is well suited to row crops but is subject to sheet erosion because of the slope. It dries out fairly soon after a rain. It is easy to keep in good tilth.

Many areas are large enough to be managed separately but are irregular in shape. The entire acreage is managed with adjacent nearly level or moderately sloping soils. Nearly all the acreage is used for cultivated crops, mainly corn and soybeans. Part of the acreage is in small grain, hay, or pasture.

Runoff is medium. Erosion control is needed for maximum yields and intensive production of row crops. If erosion is controlled, this soil can be used for row crops year after year. An occasional year of meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects are problems.

Some areas are difficult to terrace because of irregular slopes. A system of tile outlet terraces may be needed to protect this soil from erosion. Contour tillage and intensive use of row crops may be more practical.

This soil stays in fairly good tilth if crop residue is returned. Additional manure is beneficial in some small moderately eroded areas.

CAPABILITY UNIT IIw-1

This unit consists of level, somewhat poorly to poorly drained Colo and Vesser soils on bottom land. Colo soils have a thick, friable to firm silty clay loam surface layer, and Vesser soils have a silt loam surface layer. The subsoil is silty clay loam.

These soils are wet because of flooding or a high water table, or both. They dry out slowly in spring and must be worked later than the better drained associated bottom land soils. Some areas tend to be cloddy, especially if worked wet. Available water capacity is high. Excessive wetness sometimes restricts plant growth and root development unless the soils are drained.

These soils are moderate to high in organic matter. Unless limed, the surface layer is slightly to medium acid in most soils. The subsoil is medium in available phosphorus and medium to low in available potassium.

These soils are well suited to row crops, but require artificial drainage or protection from overflow. Most areas are large enough to be managed separately. Corn and soybeans are the major crops in drained areas. The risk of crop loss is greater in undrained areas than in drained areas. Part of the acreage is in small grain, hay or pasture.

Colo soils are sometimes flooded and receive damaging sediment. Reseeding or replanting may be necessary. Erosion is not a hazard, but active gullies or stream channels may form. Runoff from steeper soils upslope collects on soils in this unit during heavy rains or drains across them before entering a stream or river.

These soils are suited to row crops year after year if drainage is provided. An occasional meadow or green manure crop can be grown if tilth becomes poor or if weeds or insects are problems.

Tile drains, which are commonly used, work well in these soils. Outlets are not difficult to locate. Grassed waterways are used in some areas to drain excess surface water. Excess water from runoff to adjacent slopes is controlled in some areas by diversion terraces at the base of upland slopes. Fall plowing is practical when wetness normally delays spring planting.

CAPABILITY UNIT IIw-2

This unit consists of nearly level, poorly drained Winterset and Haig soils on uplands.

These soils have a thick, friable silty clay loam surface layer. Permeability is very slow to moderately slow in the subsoil. Available water capacity is high. Runoff is slow. The water table is high during periods of high rainfall. These soils warm up more slowly than the better drained soils on the uplands, but they cannot be worked so soon after a rain because the natural drainage is poor.

These soils puddle if worked when wet and become cloddy when dry. Adequate artificial drainage is needed to provide proper aeration and a deep rooting zone for plants.

Organic-matter content is high. Unless limed, the surface layer is typically slightly acid. The subsoil is low to medium in available phosphorus and medium to low in available potassium.

These soils are well suited to row crops if drained. Erosion is not a hazard. In years of high rainfall, the poor drainage and slow runoff may delay planting and cause crops to mature late. Almost all the acreage has some type of artificial drainage and is in row crops. Average crop yields are low unless the soils are drained. Many areas are large enough to be managed separately, but some are cropped with the better drained adjacent soils.

Corn and soybeans are the main crops. Part of the acreage is in grain sorghum, small grain, and hay.

Wetness and tilth are the major management problems. The soil is suited to row crops year after year if adequately drained. An occasional year of meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects are problems.

Tile works well in the Winterset soil but not so well in the Haig soil. Providing suitable outlets is difficult in some areas because of the broad, nearly level ridgetops.

CAPABILITY UNIT IIw-3

This unit consists of nearly level to gently sloping, moderately well drained and somewhat poorly to poorly drained Nodaway and Vesser soils on low bottom land adjacent to stream channels.

These soils have a friable silt loam surface layer. The Nodaway soil has a silt loam subsoil, and the Vesser soil has a silty clay loam subsoil. Both have a high water table during periods of high rainfall and are subject to frequent flooding. Tilth is generally good if wetness is controlled. The available water capacity is high.

The organic-matter content is moderate to low. The surface layer is slightly acid to neutral. The subsoil is medium in available phosphorus and medium to low in available potassium.

These soils are well suited to row crops but need to be protected from overflow. Some areas are large enough to be managed separately, but many are managed with adjacent soils.

Corn and soybeans are the major crops. Part of the acreage is in small grain, hay, or pasture.

Erosion is not a hazard, but runoff from other soils may collect on the soils during heavy rains or drain across them before entering a stream or river.

These soils are suited to row crops year after year if fertility and tilth are maintained and if flooding is prevented. An occasional year of meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects are problems.

CAPABILITY UNIT IIw-4

This unit consists of gently sloping, somewhat poorly drained to poorly drained Colo and Ely soils on narrow valleys, low foot slopes, and benches.

These soils have a thick, friable to firm silty clay loam surface layer and a silty clay loam subsoil.

These soils are wet because of flooding from adjacent uplands, or a high water table, or both. They dry out slowly in spring and must be worked later than the better drained associated bottom land soils. Some areas tend to be cloddy, especially if worked when wet. Available water capacity is high. Excessive wetness sometimes restricts plant growth and root development unless the soils are drained.

Organic-matter content is high. Unless limed, the surface layer is slightly acid. The subsoil is very low to medium in available phosphorus and medium to low in available potassium.

These soils are well suited to row crops but require artificial drainage or protection from overflow. Few areas are managed separately. Many are narrow and are generally not planted to crops. Corn and soybeans are the major crops in drained areas. The risk of crop loss is greater in undrained areas than in drained areas. Part of the acreage is in hay or pasture.

These soils sometimes receive runoff and damaging sediment from adjacent upland soils, and reseeding or replanting is necessary. Erosion is a major hazard, and active gullies or stream channels can form. Runoff from steeper soils upslope drains across these soils before entering a stream or river.

These soils are suited to row crops year after year if drained. An occasional meadow or green manure crop can be grown if tilth becomes poor or weeds or insects are problems.

Tile drains, which are commonly used, work well in these soils. Outlets are not difficult to locate. Grassed waterways are used in some areas to drain excess surface water. Excess water from runoff of adjacent slopes is controlled in some areas by diversion terraces at the base of upland slopes. Fall plowing is practical if wetness delays spring planting.

CAPABILITY UNIT IIIe-1

The one soil in this unit, Arispe silty clay loam, 5 to 9 percent slopes, is a moderately sloping, moderately well drained to somewhat poorly drained soil on uplands.

This soil has a friable silty clay loam surface layer and a friable to firm silty clay loam subsoil. It is moderately slowly permeable. It has a high available water capacity and medium to high runoff.

Fertility is average. The organic-matter content is moderate. Unless limed, the surface layer is slightly acid. The subsoil is very low to low in available phosphorus and low to medium in available potassium.

This soil is well suited to row crops. Areas are generally large enough to be managed separately but are sometimes farmed with less sloping soils or with steeper soils.

The major limitation is erosion. Row crops can be grown if erosion is controlled and grass waterways are maintained to prevent gully formation. If only contouring is used in erosion control, more meadow and fewer row crops should be grown. Many areas of this soil need additional lime. Row crops require additional fertilization.

CAPABILITY UNIT IIIe-2

This unit consists of moderately and strongly sloping, moderately well drained Nira, Ladoga, and Sharpsburg soils on uplands and high benches.

These soils have a friable light silty clay loam or silt loam surface layer and a friable or firm silty clay loam subsoil. Permeability is moderately slow in the subsoil.

These soils are moderately well drained and well aerated. Runoff is medium to rapid. Erosion ranges from slight to moderate, depending on past use and management. The available water capacity is high to medium. Properties are favorable for good, deep root development.

These soils have average fertility. The organic-matter content is moderate. The subsoil is very low to medium in available phosphorus and available potassium. Unless limed, the surface layer is slightly to medium acid in most soils. Tilth is good in most places but is poor in small, severely eroded areas where the subsoil is exposed. These eroded soils are hard and cloddy when dry.

These soils are well suited to crops. Most of the acreage is cropped to corn, soybeans, small grain, and hay. If managed with soils of lower capabilities, these soils are also well suited to pasture grasses, trees, or wildlife habitat.

These soils are subject to erosion unless protected by vegetation or soil conservation practices. Winter cover crops, manure, and crop residue increase the organic-matter content, improve tilth, and help control erosion. Row crops can be grown occasionally if terraces are used. If only contouring is used, more meadow and fewer row crops should be grown. Grassed waterways are needed in many places.

Spreading barnyard manure and returning crop residue to the soil are especially beneficial on eroded soils. Many areas need lime. Additional fertilization is needed if row crops are grown. Green manure crops can provide some of the needed nitrogen.

CAPABILITY UNIT IIIe-3

This unit consists of gently and moderately sloping, moderately well drained to somewhat poorly drained Pershing and Weller soils on uplands and high benches.

These soils have a friable silt loam surface layer and a light colored, platy subsurface layer. The subsoil is firm silty clay. Permeability is slow. The available water capacity is high.

Runoff is rapid. Erosion is slight to severe, depending on past use and management.

Fertility is below average. Organic-matter content is moderately low to moderate. The subsoil is high to medium in available phosphorus and very low in available potassium. Unless limed, the surface layer is medium to strongly acid. Tilth is poor in eroded areas, and the soils are somewhat cloddy when dry.

These soils are moderately well suited to row crops and well suited to small grain, alfalfa, pasture grasses, and woody vegetation. Areas are irregular in size and shape. Most are managed with adjacent soils. In some places these soils are wooded.

Erosion is a severe hazard in cultivated areas. Winter cover crops, manure, and crop residue on the soil increase the absorption rate and slow runoff, increase the organic-matter content, improve tilth, and help control erosion.

These soils are suited to row crops occasionally if erosion is controlled and grassed waterways are maintained to prevent gullying. If only contouring is used to control erosion, more meadow and fewer crops should be grown. Additional fertilization is needed if row crops are grown because of the low natural fertility.

CAPABILITY UNIT IIIe-4

This unit consists of moderately well drained and somewhat poorly drained, moderately sloping Mystic, Adair, Lamoni, and Armstrong soils on uplands.

The surface layer is friable silty clay loam, clay loam, or loam. The subsoil is clay loam and silty clay or clay and is very slowly to slowly permeable. Available water capacity is moderate to high. Runoff is rapid if the subsoil is saturated.

These soils have average fertility. Organic-matter content is low to moderate. Unless limed, the surface layer is medium to strongly acid. The subsoil is low to very low in available phosphorus and very low to medium in available potassium. In eroded areas tilth is poor and the surface layer is very hard and cloddy when dry.

This unit is moderately well suited to crops commonly grown in the county. Yields range widely, depending on the frequency, amount, and intensity of rainfall. Areas are small and are managed with other soils as cropland or pasture.

The major limitations are the hazard of erosion and poor tilth. In some places the slowly permeable subsoil of Lamoni and Adair soils causes seepy spots in adjacent areas upslope, and the water seeps over the Lamoni and Adair soils.

If erosion is controlled, these soils are suited to occasional row crops. Lamoni and Adair soils are not generally terraced because they are seepy, and their firm, clayey subsoil is difficult to work and vegetate. Contour tillage is used to control erosion. Terraces are generally built on the soils upslope or downslope that are more suitable for terrace construction.

Manure, cover crops, and crop residue improve tilth and help control weeds and maintain organic matter. Grassed waterways prevent gullying from the rapid runoff. Many areas of these soils need lime. Additional fertilization is needed if row crops are grown.

CAPABILITY UNIT IIIe-5

This unit consists of moderately and strongly sloping, well drained to moderately well drained and somewhat poorly drained Caleb, Lineville, and Shelby soils on uplands and high benches.

These soils have a silt loam, clay loam, and loam surface layer. The subsoil is clay loam in the Shelby soils and silty clay in the Lineville soils. Caleb soils have a variable subsoil of loam, clay loam, or sandy clay.

Permeability ranges from moderately slow in the Caleb and Shelby soils to very slow in the Lineville soils. Runoff is medium to rapid, depending on the slope and vegetation. Erosion is slight to moderate depending on past use and management. The available water capacity is high to moderate.

Organic-matter content ranges from low to moderate. The subsoil is low to very low in available phosphorus. In Caleb and Lineville soils it is very low in available potassium, but in Shelby soils it is high. Unless limed, the surface layer is medium to slightly acid. Tilth is good in most areas but is poor in small, severely eroded areas where the subsoil is exposed. These eroded soils have poor tilth and are hard and cloddy when dry.

This unit is moderately well suited to most crops in the county. Yields range widely depending on the frequency, amount, and intensity of rainfall. Areas are small and are generally managed with other soils as cropland or pasture. Some of the acreage is wooded.

The major limitations are the hazard of erosion and poor tilth. In some areas the Lineville soil is wet because of the very slowly permeable subsoil.

If erosion is controlled, these soils are suited to occasional row crops. Contour tillage and terraces are often used in erosion control.

Manure, cover crops, and crop residue improve tilth and help control weeds and maintain the organic-matter content. Grass waterways can be used to prevent gullying from runoff. Some additional fertilization may be needed if these soils are used for row crops.

CAPABILITY UNIT IIIe-6

The one soil in this unit, Keswick loam, 5 to 9 percent slopes, is a moderately sloping, moderately well drained soil on upper side slopes and at the ends of ridges.

This soil has a surface layer of friable loam. It has a gray, platy subsurface layer and a firm clay or clay loam subsoil that is slowly permeable. Available water capacity is moderate. Runoff is medium to high.

The organic-matter content is low. Unless limed, the surface layer is strongly acid. The soil is very low to low in available nitrogen. The subsoil is very low in available phosphorus and very low in available potassium. In eroded areas tilth is poor and the surface layer is very hard and cloddy when dry.

This soil can be used for crops but it is limited by the slope, low fertility, and slow permeability. Yields range widely depending on the frequency, amount, and intensity of rainfall. Areas are generally small and are managed with other soils as cropland or pasture. In many places this soil is wooded.

This soil is subject to erosion unless protected by vegetation or soil conservation practices. Winter cover crops, manure, and crop residue increase the organic-matter content, improve tilth, and help control erosion. Additional fertilization is needed if row crops are grown.

CAPABILITY UNIT IIIw-1

The one soil in this unit, Clearfield silty clay loam, 5 to 9 percent slopes, is a poorly drained to somewhat poorly drained, moderately sloping soil on uplands.

This soil has a friable silty clay loam surface layer and a firm silty clay loam subsoil. It is poorly aerated and moderately slowly permeable. At a depth of 3 to 6 feet is a very firm, very slowly permeable, gray clay.

The subsoil becomes quickly saturated because water movement is slowed by the more impervious substrata, resulting in seepiness and wetness during periods of normal or above average rainfall. The root zone is limited and drainage is poor because of the underlying strata.

This soil is fertile and is well suited to row crops if the wetness is corrected. Tilth is good in most places and organic-matter content is high. Unless limed, the surface layer is slightly acid. The subsoil is low in available phosphorus and available potassium. Corn and soybeans are the main crops. Part of the acreage is in small grain, hay, and pasture. Undrained areas are best suited to hay and pasture.

This soil is generally managed with gently sloping and moderately sloping, adjacent soils. Interceptor tile placed just above the clayey substrata corrects the seepiness and wetness.

This soil is subject to moderate erosion because of the slope. It is suited to occasional row crops if tile and erosion control practices are used. Grassed waterways are needed in many places to control gullying.

CAPABILITY UNIT IIIw-2

This unit consists of very poorly drained to poorly drained Sperry and Belinda soils in nearly level to depressional areas on broad upland divides and terraces along the major streams.

These soils have a friable silt loam surface layer and a thick, distinct gray subsurface layer. The subsoil is firm silty clay that is very slowly permeable.

These soils dry out slowly. Water ponds and stands for long periods after a heavy rain. Good tilth is difficult to maintain. Available water capacity is high to moderately high, but the root zone is somewhat restricted by the firm subsoil and by wetness.

If the wetness is corrected, these soils are suited to row crops. They are moderately well suited to small grain and meadow. They are moderately fertile and are low to moderate in organic matter. The subsoil is very low to low in available phosphorus and very low in available potassium. Unless limed, the surface layer is slightly or medium acid.

Areas are mostly small and are managed as cropland with other better drained soils on the level ridgetops and level terraces. If drained, these soils are suited to row crops year after year. An occasional year of meadow or a green manure crop can be grown if tilth becomes poor or weeds or insects are problems.

Properly spaced drain tile may work in some areas of these soils, but others may need surface drains. Manure and crop residue improve tilth and maintain the supply of organic matter.

CAPABILITY UNIT IIIw-3

This unit consists of level, fine textured, very poorly drained to poorly drained Wabash and Humeston soils on bottom lands.

These soils have a silty clay loam surface layer that dries out very slowly and is normally cloddy and very hard when dry. Large cracks form during extended dry periods. The Humeston soil has a gray silt loam subsurface layer that does not crack so much during dry periods. The subsoil is a very firm and compact, slowly to very slowly permeable heavy silty clay loam or silty clay. The available water capacity is moderate to high. A fluctuating water table and the clayey subsoil restrict root development.

These soils are moderately well suited to most crops but are poorly suited to crops that must be planted early in spring. They are fertile and are moderate to high in organic matter, but preparing a good seed bed is difficult. Power requirements to till the soils are generally high. Unless the soil is limed, reaction ranges from slightly acid to medium acid. The subsoil is low to high in available phosphorus and very low to medium in available potassium.

Areas range widely in size and shape, but most are large. Many are managed separately. Others are managed with better drained adjacent soils. Most of the acreage is in crops.

Tile drainage does not work well on these soils. If good surface drainage is provided, these soils are suited to row crops year after year. Corn and soybeans are the principal crops. Yields depend on drainage and the frequency and amount of rainfall. Some areas are subject to overflow. Fall plowing and the return of crop residue improve the tilth.

CAPABILITY UNIT IVe-1

The one soil in this unit, Pershing silt loam, 9 to 14 percent slopes, is a moderately well drained to somewhat poorly drained, strongly sloping soil on uplands in the southeastern part of the county.

This soil has a silt loam surface layer and a light colored, platy, grayish subsurface layer. The subsoil is blocky, firm silty clay. Permeability is slow. The available water capacity is high. The root zone is deep. Runoff is rapid. Erosion is slight to severe, depending on past use and management.

This soil is moderate to moderately low in organic matter. The subsoil is high in available phosphorus and very low in available potassium. Unless limed, the surface layer is medium to slightly acid. In eroded areas, tilth is poor and the soil is somewhat cloddy when dry.

This soil is generally in crops or pasture. It is better suited to small grain, meadow, or permanent pasture than to row crops. Some of the acreage is best suited to trees or wildlife habitat, depending on the adjacent soils.

This soil is subject to erosion unless protected by vegetation or soil conserving practices. Winter cover crops, manure, and crop residue increase the organic-matter content, improve tilth, and help control erosion. Grassed waterways are needed in some areas.

CAPABILITY UNIT IVe-2

This unit consists of well drained to moderately well drained, strongly sloping and moderately steep Shelby soils on uplands. These soils have a clay loam surface layer and a firm clay loam subsoil that is moderately slowly permeable.

These soils are well drained to moderately well drained. Surface runoff is high to very high because of the strong and moderately steep slopes. They have properties favorable for good root development and a high available water capacity. They are subject to erosion and gullying.

These soils are somewhat below average in fertility. They are low to moderate in organic matter. The subsoil is low in available phosphorus and high in available potassium. Severely eroded areas are sticky when wet and become hard and cloddy when dry. Small stones and pebbles occur in some areas.

These soils are better suited to small grain, meadow, or permanent pasture than to row crops. Most of the acreage is in crops or pasture. Some areas are better suited to trees or wildlife habitat, depending on the adjacent soils.

These soils are subject to erosion and are highly susceptible if row crops are grown. They should be kept in hay or pasture most of the time. A corn crop can be grown on the contour when the stands of legumes and grasses need reseeding, generally after 4 years or more. Permanent pasture and woodland are alternate uses. Terrace construction is difficult in many places because of the irregular slopes. Even if the soils are terraced, row crops should be grown infrequently.

Most of the acreage that is used for crops is managed separately or with soils that are better suited. Areas used as permanent pasture, woodland, or wildlife habitat are generally managed with soils of lower capabilities.

CAPABILITY UNIT IVe-3

This unit consists of well drained to moderately well drained, strongly sloping Caleb and Gara soils on uplands and high benches.

The surface layer is loam. It is friable in most places. In some eroded areas where the subsoil has been mixed with the surface layer and is exposed by plowing, this layer is sticky when wet and hard when dry. The subsoil is clay loam to loam and sandy clay. It is friable to firm. Permeability is slow to moderately rapid.

Runoff is rapid in most places because of the slope. Properties are favorable for good root development. The available water capacity is high to moderate.

These soils are not well suited to row crops but are moderately well suited to pasture. Natural fertility is low, and tilth is poor in most areas. The organic-matter content is moderate to low. The subsoil is very low to low in available phosphorus and very low in available potassium. Unless limed, the surface layer is strongly acid. Erosion is a serious problem, and gullies form easily.

Most of the acreage is in crops, chiefly row crops, small grain, and grasses and legumes for hay and pasture. Contour tillage is a common practice, and grassed waterways are maintained to prevent gully formation. Terracing is practical in some areas. Even if erosion is controlled, these soils are suited to row crops only occasionally. They should be kept in hay or pasture most of the time. A year of row crops can be grown on the contour when stands of grasses and legumes need reseeding, usually after 4 years or more.

Some small areas managed with the better suited adjacent soils can be cropped more intensively. Others, with less suitable soils, should be managed as pasture or woodland.

CAPABILITY UNIT IVe-4

This unit consists of moderately well drained to very poorly drained, strongly sloping Mystic, Caleb, Lamoni, Adair, Shelby, Clarinda, and Armstrong soils on uplands and high benches.

The surface layer is silty clay loam, clay loam, or loam. It is friable in most places. In some eroded areas where the subsoil has been mixed with the surface layer and exposed by plowing, this layer is sticky when wet and hard when dry. The subsoil is heavy clay loam to clay. It is firm to very firm and is moderately to very slowly permeable.

Runoff is rapid in most places. In most of the soils the movement of air and water is somewhat restricted. Saturation in the Lamoni and Clarinda soils causes narrow seepy areas upslope in the more permeable loess soils. Available water capacity is moderate to high. Root penetration is restricted in the subsoil in most of these soils.

These soils are not well suited to row crops but are moderately well suited to pasture. Natural fertility is low and tilth is poor in most areas. The organic-matter content is low to moderate. The subsoil is very low to low in available phosphorus and very low to medium in available potassium. Unless limed, the soils are medium to strongly acid. Erosion is a serious problem. Gullies form easily.

Most of the acreage is in crops, chiefly row crops, small grain, and grasses and legumes for hay and pasture. Contour tillage is a common practice. Grassed waterways are maintained to prevent gully formation. Terracing is practical in some areas. Because the subsoil is mostly clayey and dense, good management is needed to restore productivity in the terrace channels. Even if erosion is controlled, these soils are seldom suited to row crops. They should be kept in hay or pasture most of the time. A year of row crops can be grown on the contour when stands of grasses and legumes need reseeding, usually after 4 years or more.

Some small areas can be cropped more intensively with better suited adjacent soils. Others, with less suitable soils, should be managed as pasture or woodland.

CAPABILITY UNIT IVe-5

This unit consists of Gara-Armstrong loams, 9 to 14 percent slopes, moderately eroded. These soils are strongly sloping, moderately well drained to somewhat poorly drained soils on uplands.

The surface layer is thin, friable, and loamy. The subsoil is firm clay and clay loam that is slowly to moderately slowly permeable. Runoff is rapid. The available water capacity is high and moderately high.

These soils are very poorly suited to row crops and are poorly suited to small grain and meadow. They are moderately well suited to pasture or woodland. Organic-matter content is low to moderate. The subsoil is very low to low in available phosphorus and available potassium. Unless limed, the surface layer is strongly acid.

Areas are small, and most of the acreage is managed with steeper adjacent soils as permanent pasture or woodland. In some areas a row crop can be grown on the contour when stands of grasses and legumes need reseeding, usually after 4 years or more of pasture and hay. Some of the existing permanent pasture can be renovated and more productive pasture plants introduced.

Fencing out livestock and good woodland management help increase the productivity of many areas presently in woodland.

CAPABILITY UNIT IVe-6

The one soil in this unit, Dickinson fine sandy loam, 5 to 14 percent slopes, is a thin, moderately sloping and strongly sloping, well drained soil on ridges or side slopes of the uplands or high benches.

This soil has a friable fine sandy loam surface layer that absorbs water readily. The subsoil is a friable to loose, rapidly permeable loamy sand or sandy loam.

The available water capacity is low to moderate. The root zone is favorable.

The organic-matter content is moderately low, and the supply of available plant nutrients is very low. Unless limed, the surface layer is medium acid to slightly acid.

This soil is droughty. It readily absorbs rainfall but holds little moisture available for plants. It warms up quickly in spring and can be worked soon after a rain. Tilth is generally good.

This soil is generally used for row crops because it occurs as small areas within larger areas of more suitable soils. It is susceptible to soil blowing and sheet erosion. Blowing sand sometimes damages new seedings on this soil or on adjacent soils. Good management is needed. Leaving crop residue on the surface helps control soil blowing.

CAPABILITY UNIT IVw-1

This unit consists of moderately sloping, very poorly drained Clarinda soils on uplands near the heads of drainageways.

The surface layer is silty clay loam. It is generally friable and absorbs water well. In eroded areas, however, the surface layer is somewhat firm, and runoff is more rapid. The subsoil is a very firm gray silty clay. It has a high available water capacity but is very slowly permeable, very poorly drained, and poorly aerated. These factors severely limit root growth.

These soils remain wet and saturated for long periods. Because of the very slow permeability, seepy areas occur where these soils are adjacent to the more permeable soils upslope. Seepage water moves downslope and increases the wetness of the Clarinda soils.

These soils are poorly suited to crops and are only moderately well suited to pasture because of the wetness. They are slightly to medium acid. Fertility is low, and the organic-matter content is moderate. The subsoil is low in available phosphorus and low to medium in available potassium.

Areas of these soils are small and irregular. They are managed with other soils as cropland or pasture. Many small areas within cultivated acreages are left idle.

Tile drains are not effective. In some areas, interceptor tile placed in the more permeable soils upslope hastens drying, allows for more timely tillage, and promotes the growth of more suitable grasses. If cropped, these soils are subject to erosion.

These soils are best suited to hay or pasture. Unless wetness is too serious a problem, a row crop can be grown when stands of hay or pasture crops become poor and need reseeding. These soils are generally so wet that alfalfa does not grow well. Other more water-tolerant legumes are better suited to the wetter areas.

Terraces are not suitable because the fine textured subsoil is exposed in terrace channels and is very difficult to vegetate. Terraces should be constructed in soils above or below these soils.

CAPABILITY UNIT Vw-1

The one soil in this unit, Nodaway silt loam, 0 to 2 percent slopes, channeled, is an alluvial soil along small intermittent streams and their branches, which form in the uplands, and along the major streams and tributaries. It is subject to frequent overflow. Areas along the major streams and tributaries are nearly level and have a larger number of meandering stream channels and surface drains.

On the narrow stream bottoms, the surface layer is lighter colored and coarse textured. Near the larger streams the major limitations are longer periods of flooding, streambank erosion, ponding in low areas, and deposition of sandy material.

Most of the acreage along small intermittent streams and small branching waterways is in pasture. A small part is managed as cropland with adjacent soils. Areas near the larger streams are in trees and brush.

This soil is not suited to crops because of flooding, gullying, or channels. Stream straightening, channel filling and shaping, tree and brush clearing, and drainage are used in some areas to convert this soil to cropland or improved pasture. Reclaimed areas are managed with adjacent soils better suited to cultivation.

CAPABILITY UNIT VIe-1

This unit consists of well drained to moderately well drained, moderately steep and steep Shelby and Caleb soils on uplands and high benches.

In most places the surface layer is loam to light clay loam. In severely eroded areas it is mixed with the lighter colored subsoil material, which has been exposed by plowing. The subsoil is light to heavy clay loam. It is moderately slowly permeable and slowly permeable and well aerated.

Runoff is rapid because of the steep slopes. Unless protected, these soils are subject to erosion. Gullies form easily in waterways.

These soils are somewhat low in fertility. The subsoil is very low to low in available phosphorus and very low to high in available potassium. Organic-matter content is low to moderate. Unless limed, most areas are strongly to medium acid.

Because of the slope and very high runoff, these soils are not suited to row crops. They are well suited to pasture, trees, or wildlife habitat.

Most areas are in bluegrass pasture. Farm machinery can be used in many areas to prepare a seedbed for more productive grasses and legumes. Mowing weeds and controlling grazing increase the production of existing pastures.

CAPABILITY UNIT VIe-2

This unit consists of moderately steep, moderately eroded, well drained to somewhat poorly drained Adair-Shelby clay loams on uplands.

These soils have a friable to firm clay loam surface layer. The subsoil is firm clay loam to clay. It is moderately slowly to slowly permeable and poorly aerated.

These soils have a moderately high and high available water capacity. In places root development is restricted by the clayey, impermeable subsoil. In eroded areas the surface layer is mixed with subsoil material, which has been exposed by plowing. The soils in these areas are sticky when wet and hard when dry.

Most of these soils have low fertility. The subsoil is very low to low in available phosphorus and very low to high in available potassium. Organic-matter content is low to moderate. Unless limed, the surface layer is typically medium acid.

These soils are not suited to row crops. They are moderately well suited to pasture and are well suited to wildlife habitat. The most serious limitation is erosion. In some areas wetness and seepage from more permeable soils upslope limit the choice of plants and management.

Most areas are in pasture. Some small areas within areas of more suitable soils are managed as cropland.

Mowing weeds, controlling grazing, and seeding to more productive grasses and legumes increase the carrying capacity of pasture. Interceptor tile placed in adjacent soils upslope reduces wetness in some areas and helps to establish deep rooted legumes.

Most of the acreage is suitable for farm pond construction. Many sites are available.

CAPABILITY UNIT VIe-3

This unit consists of moderately steep, well drained to somewhat poorly drained Gara and Lindley soils and Gara-Armstrong loams on uplands.

These soils have a friable loam surface layer. The subsoil is firm clay and clay loam. It is moderately slowly to slowly permeable.

These soils have moderately high to high available water capacity. Runoff is very high because of the slope.

These soils are low in natural fertility and moderate to low in organic-matter content. The subsoil is very low to low in available phosphorus and available potassium. Unless limed, the surface layer is strongly acid to medium acid.

These soils are not suited to row crops. They are moderately well suited to pasture and well suited to woodland or wildlife. The most serious limitation is erosion.

Most areas are pasture or woodland pasture. Some within areas of more suitable soils are managed as cropland.

Mowing weeds, controlling grazing, and seeding to more productive grasses and legumes increase the carrying capacity of pastures. Many areas in woodland pasture would be more productive if livestock were fenced out and the woodland well managed.

Most of the acreage is suitable for farm pond construction. Many sites are available.

CAPABILITY UNIT VIIe-1

This unit consists of well drained to moderately well drained, steep, moderately eroded Gara and Lindley soils on uplands.

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 mainly firm clay loam.

These soils are moderately slowly permeable. Runoff is very rapid because of the steep slopes. Gullies form rapidly. The available water capacity is high, and properties are favorable for deep root development of grasses and trees.

Fertility is very low to medium. The subsoil is very low to low in available phosphorus and available potassium. The organic-matter content is low to moderate in the surface layer. The soils are typically medium or strongly acid.

These soils are not suited to crops and are severely limited for pasture because of the steep slopes. They are suited to woodland and wildlife habitat.

Areas range from large to small. They are mainly pasture, wooded pasture, or woodland. In areas that are not too steep for farm machinery, mowing and seeding the more productive grasses and legumes increase the capacity of pastures.

Selective cutting and removal of undesirable trees and brush improve the yield of woodland products. Many timbered areas that are now pasture would be more productive of wood crops if livestock were fenced out and the woodland well managed. Properties are favorable for pond construction, gully control, water supply, and 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 than those indicated in the table because of variations in rainfall and other climatic factors. Absence of an estimated yield indicates that the crop is not suited to or not commonly grown on the soil or that a given crop is not commonly irrigated.

The estimated yields were 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 the most productive varieties of grasses and legumes suited to the climate and 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; the 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 residues, barnyard manure, and green-manure crops; harvesting crops with the smallest possible loss; and timeliness of all fieldwork.

The estimated yields reflect the productive capacity of the soils for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 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 management concerns and productivity of the soils for these crops.

Woodland Management and Productivity

Table 3 contains information useful to woodland

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

[All yields were estimated for a high level of management in 1975. Absence of a yield figure indicates the crop is seldom grown or is not suited]

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	114	43	65	4.8	8.0	4.2
Colo:						
[2] 11B	105	40	60	4.4	6.0	4.1
Nodaway:						
[2] 13B	89	34	55	3.7	5.8	3.6
Arispe:						
23C	105	40	57	4.4	6.3	3.8
Shelby:						
24C	93	35	51	3.9	5.3	3.7
24C2	90	34	50	3.8	5.3	3.5
24D	84	32	46	3.5	5.0	3.3
24D2	81	31	44	3.4	4.9	3.3
24D3	75	29	41	3.2	4.5	2.7
24E	69	26	38	2.9	4.1	2.3
24E2	66	25	36	2.7	4.0	2.1
24F2						1.7
Vesser:						
51	95	36	52	4.0	5.0	3.7
Lindley:						
65E				2.0	3.4	
65F					2.0	
Clearfield:						
69C	91	35	50	3.6	5.9	3.5
Ladoga:						
76B, T76B	113	43	62	4.7	7.8	4.3
76C, T76C	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
Adair:						
[2] 93D	73	28	40	3.1	4.2	2.7
[2] 93D2	68	26	37	2.9	4.0	2.7
[2] 93E2				2.5	3.2	2.0
Mystic:						
[2] 94D2	59	22	32	2.4	3.1	2.0
Sperry:						
122	97	37	53	3.5	5.1	3.6
Belinda:						
T130	87	33	48	3.7	6.2	3.7

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]
Pershing:						
131C, T131C	96	36	53	4.0	6.7	3.5
131C2	91	33	50	3.8	6.4	3.4
131D	85	33	46	3.6	6.0	3.4
T131B	101	38	56	4.2	7.0	3.8
Weller:						
132C	90	34	50	3.8	6.4	3.7
Colo:						
133	104	40	78	4.2	5.5	4.2
133B	102	39	76	4.0	5.3	4.2
Dickinson:						
175D	67	25	50	2.3	4.0	2.0
Gara:						
179D	78	30	43	3.3	4.7	2.7
179D2	75	28	41	3.1	4.5	2.5
179E	---	---	---	2.5	3.3	1.7
179E2	---	---	---	2.2	---	1.5
179F	---	---	---	1.5	---	1.3
Adair:						
192C	73	28	40	3.1	4.0	2.7
192C2	65	25	36	2.7	3.5	2.3
192D2	54	20	30	2.3	2.9	1.9
Kennebec:						
212	118	45	67	5.0	7.0	4.1
Nodaway:						
220	110	42	60	4.6	6.5	4.0
C220	---	---	---	3.0	5.5	4.0
Clarinda:						
222C	63	24	34	2.6	3.7	2.7
222C2	55	21	30	2.2	3.3	2.3
222D	54	20	30	2.1	3.1	2.1
222D2	46	17	25	1.8	2.9	1.7
Wabash:						
248	86	33	47	2.5	4.1	3.3
Humeston:						
269	88	33	48	3.7	5.0	3.3
Olmitz:						
273B	100	38	55	4.2	6.0	3.9
Haig:						
362	105	40	58	4.2	7.0	3.8
Grundy:						
364B	107	41	59	4.5	6.6	3.6

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]
Macksburg:						
368	121	46	67	5.1	8.4	4.5
368B	117	44	64	4.9	8.2	4.2
Winterset:						
369	117	44	64	4.9	8.2	4.3
Sharpsburg:						
370B	113	43	62	4.7	7.8	4.2
370C	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
Nira:						
[2] 371C	110	42	61	4.6	7.6	4.1
[2] 371C2	107	40	59	4.5	7.4	4.0
Keswick:						
425C	61	23	33	2.6	3.7	2.1
Caleb:						
451C2	76	29	41	3.1	4.4	2.7
451D2	66	25	36	2.8	4.0	2.1
451E2	----	----	20	1.9	3.3	1.7
Lineville:						
452C	70	27	38	2.9	3.5	2.5
Mystic:						
592C2	60	23	33	2.5	3.0	2.1
592D2	51	19	28	2.0	2.3	1.9
Armstrong:						
792C	67	25	36	2.7	3.3	2.3
792C2	59	22	33	2.5	3.1	2.1
792D2	50	19	28	2.0	2.7	1.7
Lamoni:						
822C	76	29	42	3.2	4.5	3.0
822C2	71	27	39	3.0	4.3	2.7
822D	66	25	36	2.7	4.0	2.3
822D2	61	23	33	2.6	3.7	2.1
Gara:						
[2] 993D2	67	25	37	2.8	3.9	2.3
[2] 993E2	60	23	33	1.8	3.0	1.5

[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 of the whole mapping unit.

TABLE 3.—*Woodland management and productivity*

[Only the soils suitable for production of commercial trees are listed in this table. Absence of an entry in a column means the information was not available]

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	
Judson: 8B	2o	Slight	Slight	Slight	Moderate	Black walnut White oak Northern red oak	73 --- ---	Black walnut, eastern cottonwood, green ash.
Nodaway: [1] 13B: Nodaway part Vesser part.	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.
Lindley: 65E, 65F	4r	Moderate	Moderate	Slight	Slight	White oak Post oak Blackjack oak Black oak	60 --- --- ---	White oak, green ash, yellow-poplar, post oak, blackjack oak, black oak.
Ladoga: 76B, 76C, 76C2, 76D, T76B, T76C	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.
Mystic: [1] 94D2: Mystic part	3o	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple.
Caleb part	3o	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple.
Belinda: T130	5w	Slight	Moderate	Moderate	Severe	White oak	45	Eastern cottonwood, silver maple, laurel willow, American sycamore, green ash, northern white-cedar.

Pershing:								
131C, 131C2, 131D, T131B, T131C	4c	Slight	Slight	Slight	Slight	White oak	55	Eastern white pine, Scotch pine, Norway spruce, red pine, white spruce.
Weller:								
132C	4c	Slight	Slight	Slight	Slight	White oak	55	Eastern white pine, Scotch pine, Norway spruce, white spruce, red pine, European larch, black walnut, sugar maple.
Dickinson:								
175D	---	---	---	---	---	---	---	Eastern white pine, red pine, jack pine.
Gara:								
179E, 179E2, 179F	3r	Moderate	Moderate	Slight	Slight	White oak	55	Eastern white pine, red pine, Norway spruce, Scotch pine.
						Northern red oak	55	
Kennebec:								
212	2o	Slight	Slight	Slight	Moderate	Black walnut	79	Black walnut, bur oak, hackberry, green ash, eastern cottonwood, American sycamore.
						Bur oak	63	
						Hackberry	---	
						Green ash	---	
						Eastern cottonwood	---	
Nodaway:								
220, C220	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.
Wabash:								
248	4w	Slight	Moderate	Moderate	Severe	Pin oak	75	Pin oak, pecan, eastern cottonwood.
Grundy:								
364B	---	---	---	---	---	---	---	Eastern cottonwood, pin oak.
Sharpsburg:								
370B, 370C, 370C2, 370D	4o	Slight	Slight	Slight	Slight	Black oak	60	Black walnut, hackberry, green ash.
						Black walnut	60	
						White oak	---	
						Hackberry	---	
						Green ash	---	
Nira:								
[1]371C:								
Nira part.								
Sharpsburg part	4o	Slight	Slight	Slight	Slight	Black oak	60	Black walnut, hackberry, green ash.
						Black walnut	60	
						White oak	---	
						Hackberry	---	
						Green ash	---	

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	
[1] 371C2: Nira part. Sharpsburg part	4o	Slight	Slight	Slight	Slight	Black oak Black walnut White oak Hackberry Green ash	60 60 --- --- ---	Black walnut, hackberry, green ash.
Keswick: 425C	3c	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, European larch, white spruce, sugar maple.
Caleb: 451D2	3o	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple.
451E2	3r	Moderate	Moderate	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple.
Mystic: 592C2, 592D2	3o	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple.
Armstrong: 792C, 792C2, 792D2	4c	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple, poplars.
Gara: [1] 993D2: Gara part	3o	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine.
Armstrong part	4c	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple, poplars.

[1] 993E2:								
Gara part	3r	Moderate	Moderate	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine.
Armstrong part	4c	Slight	Slight	Slight	Slight	White oak Northern red oak	55 55	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, European larch, black walnut, sugar maple, poplars.

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

owners or forest managers planning use of soils for wood crops. Map unit symbols for soils suitable for wood crops are listed, and the ordination (woodland suitability) symbol for each soil is given. All soils bearing the same ordination symbol require the same general kinds 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*, restricted root depth; *c*, clay in the upper part of the soil; *s*, sandy texture; *f*, high content of coarse fragments in the soil profile; and *r*, steep slopes. The letter *o* indicates insignificant 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; *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; *severe* means 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 material, and water management. Among those who can benefit from this information are engineers, landowners, community planners, town and city managers, land developers, builders, contractors, and 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 a soil survey and used in determining the ratings in this section were 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 high 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 uses; (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 structures 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, testing, and analysis by personnel having expertise in the specific use contemplated.

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, the soil descriptions, and other data provided in this survey, can be used to make additional interpretations and to 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 generally are favorable for the specified use; any limitation is minor and is easily overcome. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates that 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, and open ditches. Such digging or trenching is influenced by 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 no 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 of the structure 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 large stones in or on the soil are also important considerations in the choice of sites for these structures and were considered in determining the ratings. Susceptibility to flooding is a serious hazard.

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 classifications of the soil and the soil texture, density, shrink-swell potential, and potential frost action 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. It is important to observe local ordinances and regulations.

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

TABLE 4.—*Building site development*

[Some 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.
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.
Ely part	Severe: wetness	Moderate: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.
Nodaway:					
[1] 13B:					
Nodaway part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action.
Vesser part	Severe: wetness, floods.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, frost action.
Arispe:					
23C	Moderate: wetness.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Shelby:					
24C, 24C2	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength, slope.	Severe: low strength.
24D, 24D2, 24D3	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.
Vesser:					
51	Severe: wetness, floods.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, frost action.
Lindley:					
65E, 65F	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Clearfield:					
69C	Severe: wetness	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.
Ladoga:					
76B, T76B	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: frost action.
76C, 76C2, T76C	Moderate: wetness.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: frost action.
76D	Moderate: slope, wetness.	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: shrink-swell, slope.	Severe: frost action.

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
Adair:					
[1] 93D:					
Adair part	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Shelby part	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
[1] 93D2:					
Adair part	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Shelby part	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
[1] 93E2:					
Adair part	Severe: wetness, too clayey.	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Shelby part	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Mystic:					
[1] 94D2:					
Mystic part	Moderate: wetness, slope, too clayey.	Moderate: wetness, shrink-swell, slope.	Moderate: wetness, shrink-swell, slope.	Severe: slope	Severe: low strength, frost action.
Caleb part	Moderate: wetness.	Moderate: slope, shrink-swell.	Moderate: wetness, slope.	Severe: slope	Severe: low strength.
Sperry:					
122	Severe: too clayey, wetness.	Severe: wetness, shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: frost action, wetness, shrink-swell.
Belinda:					
T130	Severe: wetness	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.	Severe: shrink-swell, wetness.
Pershing:					
131C, 131C2, T131B, T131C	Moderate: wetness.	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength, frost action.
131D	Moderate: wetness, slope.	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength, frost action.
Weller:					
132C	Severe: wetness	Severe: shrink-swell.	Severe: shrink-swell, wetness.	Severe: shrink-swell.	Severe: shrink-swell, frost action, low strength.
Colo:					
133, 133B	Severe: wetness, floods.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, low strength, frost action.
Dickinson:					
175D	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.

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
Gara: 179D, 179D2	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
179E, 179E2, 179F	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Adair: 192C, 192C2, 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, C220	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action.
Clarinda: 222C, 222C2, 222D, 222D2	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.
Wabash: 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.
Humeston: 269	Severe: wetness	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: wetness low strength, shrink-swell.
Olmitz: 273B	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.
Haig: 362	Severe: wetness, too clayey.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.
Grundy: 364B	Severe: wetness	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
Macksburg: 368, 368B	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: 369	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: 370B, 370C, 370C2	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
370D	Moderate: slope	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, slope.	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
Nira:					
[1]371C:					
Nira part	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: frost action, low strength, shrink-swell.
Sharpsburg part.	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
[1]371C2:					
Nira part	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: frost action, low strength, shrink-swell.
Sharpsburg part.	Slight	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.
Keswick:					
425C	Severe: wetness	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: low strength, shrink-swell, frost action.
Caleb:					
451C2	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: slope, shrink-swell.	Severe: low strength.
451D2	Moderate: wetness.	Moderate: slope, shrink-swell.	Moderate: wetness, slope.	Severe: slope	Severe: low strength.
451E2	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Lineville:					
452C	Severe: wetness	Severe: low strength, wetness.	Severe: shrink-swell, wetness, low strength.	Severe: wetness, low strength.	Severe: low strength, frost action.
Mystic:					
592C2	Moderate: wetness, too clayey.	Moderate: wetness, shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: wetness, shrink-swell, slope.	Severe: low strength, frost action.
592D2	Moderate: wetness, slope, too clayey.	Moderate: wetness, shrink-swell, slope.	Moderate: wetness, shrink-swell, slope.	Severe: slope	Severe: low strength, frost action.
Armstrong:					
792C, 792C2	Severe: wetness	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength, frost action.
792D2	Severe: wetness	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, frost action.
Lamoni:					
822C, 822C2, 822D, 822D2	Severe: wetness, too clayey.	Severe: shrink-swell, low strength, wetness.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, wetness, 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
Gara:					
[1] 993D2:					
Gara part	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
Armstrong part	Severe: wetness	Severe: shrink-swell, low strength.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, frost action.
[1] 993E2:					
Gara part	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
Armstrong part	Severe: wetness, slope.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, wetness, low strength.	Severe: shrink-swell, low strength, slope.	Severe: shrink-swell, low strength, 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 of the whole mapping unit.

erties 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,* or *poor,* which, respectively, mean about the same as the terms *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 on 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 may be contaminated.

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 and cut slopes or embankments of compacted soil material. Aerobic lagoons generally are designed to hold sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water. Soils that are very high in content of organic matter and those that have cobbles, stones, or 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. In soils 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. 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 are not subject to flooding. 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. Soil wetness can be a limitation, because operating heavy equipment on a wet soil is difficult. Seepage into the refuse increases the risk of pollution of ground water.

Ease of excavation affects the suitability of a soil for the trench type of landfill. A suitable soil is deep to bedrock and free of large stones and boulders. If the seasonal water table is high, water will seep into trenches.

Unless otherwise stated, the limitations in table 5 apply only to the soil material within a depth of about

TABLE 5.—*Sanitary facilities*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms used to rate soils]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Judson:					
8B	Slight	Moderate: slope, seepage.	Moderate: too clayey.	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.
Ely part	Severe: wetness	Moderate: excess humus, seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
Nodaway:					
[1] 13B:					
Nodaway part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
Vesser part	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
Arispe:					
23C	Severe: percs slowly.	Severe: slope	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey.
Shelby:					
24C, 24C2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey, slope.
24D, 24D2, 24D3	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.
Vesser:					
51	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
Lindley:					
65E, 65F	Severe: percs slowly, slope.	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
Clearfield:					
69C	Severe: percs slowly, wetness.	Severe: slope	Severe: wetness	Severe: wetness	Fair: too clayey.
Ladoga:					
76B, T76B	Severe: percs slowly.	Moderate: slope	Moderate: too clayey.	Slight	Fair: too clayey.
76C, 76C2, T76C	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
76D	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
Adair:					
[1] 93D:					
Adair part	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Moderate: slope	Poor: area reclaim.
Shelby part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
[1] 93D2:					
Adair part	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Moderate: slope	Poor: area reclaim.
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 lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
[1] 93E2: Adair part	Severe: percs slowly, slope.	Severe: slope	Severe: wetness, too clayey.	Severe: slope	Poor: area reclaim.
Shelby part	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope.
Mystic: [1] 94D2: Mystic part	Severe: percs slowly, wetness.	Severe: slope, wetness, seepage.	Severe: seepage, wetness.	Moderate: wetness.	Fair: area reclaim.
Caleb part	Moderate: wetness, slope.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.
Sperry: 122	Severe: percs slowly, wetness.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness, area reclaim.
Belinda: T130	Severe: percs slowly, wetness.	Slight	Severe: wetness	Severe: wetness	Poor: wetness, too clayey.
Pershing: 131C, 131C2, T131C	Severe: percs slowly, wetness.	Severe: slope	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey.
131D	Severe: percs slowly, wetness.	Severe: slope	Moderate: too clayey, wetness.	Moderate: wetness, slope.	Fair: too clayey, slope.
T131B	Severe: percs slowly, wetness.	Moderate: slope	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey.
Weller: 132C	Severe: percs slowly.	Severe: slope	Severe: wetness	Moderate: wetness.	Fair: too clayey.
Colo: 133, 133B	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Dickinson: 175D	Moderate: slope	Severe: seepage, slope.	Severe: seepage	Severe: seepage	Fair: slope, thin layer.
Gara: 179D, 179D2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
179E, 179E2, 179F	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope, area reclaim.
Adair: 192C, 192C2	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Slight	Poor: area reclaim.
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, C220	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Good.
Clarinda: 222C, 222C2, 222D, 222D2	Severe: percs slowly, wetness.	Severe: slope	Severe: too clayey, wetness.	Severe: wetness	Poor: area reclaim, too clayey.

TABLE 5.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
Wabash:					
248	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness, too clayey.
Humeston:					
269	Severe: wetness	Severe: floods, wetness.	Severe: wetness	Severe: wetness	Poor: wetness.
Olmitz:					
273B	Moderate: percs slowly.	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: thin layer.
Haig:					
362	Severe: percs slowly, wetness.	Moderate: excess humus, wetness.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Grundy:					
364B	Severe: percs slowly, wetness.	Moderate: slope	Moderate: too clayey, wetness.	Moderate: wetness.	Fair: too clayey.
Macksburg:					
368	Severe: percs slowly, wetness.	Moderate: wetness, excess humus.	Moderate: wetness.	Moderate: wetness.	Fair: too clayey.
368B	Severe: percs slowly, wetness.	Moderate: slope, wetness, excess humus.	Moderate: wetness.	Moderate: wetness.	Fair: too clayey.
Winterset:					
369	Severe: percs slowly, wetness.	Moderate: wetness, excess humus.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
Sharpsburg:					
370B	Severe: percs slowly.	Moderate: slope	Moderate: too clayey.	Slight	Fair: too clayey.
370C, 370C2	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
370D	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: slope, too clayey.
Nira:					
[1] 371C:					
Nira part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
Sharpsburg part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
[1] 371C2:					
Nira part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
Sharpsburg part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
Keswick:					
425C	Severe: percs slowly.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.
Caleb:					
451C2	Moderate: wetness.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.
451D2	Moderate: wetness, slope.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.

TABLE 5.—*Sanitary facilities*—Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
451E2	Severe: slope	Severe: slope	Severe: wetness	Severe: slope, wetness.	Poor: area reclaim, slope.
Lineville: 452C	Severe: percs slowly, wetness.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.
Mystic: 592C2, 592D2	Severe: percs slowly, wetness.	Severe: slope, wetness, seepage.	Severe: seepage, wetness.	Moderate: wetness.	Fair: area reclaim.
Armstrong: 792C, 792C2, 792D2	Severe: percs slowly.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.
Lamoni: 822C, 822C2, 822D, 822D2	Severe: percs slowly.	Severe: slope	Severe: wetness, too clayey.	Severe: wetness	Poor: area reclaim, too clayey.
Gara: [1] 993D2: Gara part	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
Armstrong part	Severe: percs slowly.	Severe: slope	Severe: wetness	Severe: wetness	Poor: area reclaim.
[1] 993E2: Gara part	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope, area reclaim.
Armstrong part	Severe: percs slowly, slope.	Severe: slope	Severe: wetness	Severe: wetness, slope.	Poor: area reclaim, 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 of the whole mapping unit.

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.

Daily cover for landfill should be soil that is easy to excavate and spread over the compacted fill in wet and dry periods. 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. These factors include 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 materials. Each soil is evaluated to the depth observed, generally about 6 feet.

Roadfill is soil material used in embankments for roads. Soils are evaluated as a source of roadfill for low embankments, which generally are less than 6 feet high and less exacting in design than high embankments. The ratings reflect the ease of excavating and working the material and the expected performance of the material where 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 some of the soil properties that influence such performance is given in the descriptions of the soil series.

The ratings apply to the soil material between the A horizon and a depth of 5 to 6 feet. It is assumed that

TABLE 6.—*Construction materials*

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

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Judson:				
8B	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
Colo:				
[1] 11B:				
Colo part	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Ely part	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
Nodaway:				
[1] 13B:				
Nodaway part	Poor: frost action	Unsuited	Unsuited	Good.
Vesser part	Poor: frost action	Unsuited	Unsuited	Poor: wetness.
Arispe:				
23C	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: too clayey.
Shelby:				
24C, 24C2	Poor: low strength	Unsuited	Unsuited	Fair: thin layer.
24D, 24D2, 24D3	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
24E, 24E2, 24F2	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Vesser:				
51	Poor: frost action	Unsuited	Unsuited	Poor: wetness.
Lindley:				
65E, 65F	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Clearfield:				
69C	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
Ladoga:				
76B, 76C, 76C2, T76B, T76C	Poor: frost action	Unsuited	Unsuited	Fair: thin layer.
76D	Poor: frost action	Unsuited	Unsuited	Fair: thin layer, slope.
Adair:				
[1] 93D:				
Adair part	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
Shelby part	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
[1] 93D2:				
Adair part	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
Shelby part	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
[1] 93E2:				
Adair part	Poor: low strength, area reclaim.	Unsuited	Unsuited	Poor: area reclaim.
Shelby part	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Mystic:				
[1] 94D2:				
Mystic part	Poor: low strength	Unsuited	Unsuited	Poor: area reclaim.
Caleb part	Fair: area reclaim	Unsuited	Unsuited	Poor: area reclaim.

TABLE 6.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Sperry: 122	Poor: area reclaim, shrink-swell, wetness.	Unsuited	Unsuited	Poor: area reclaim, wetness.
Belinda: T130	Poor: shrink-swell, wetness.	Unsuited	Unsuited	Fair: area reclaim.
Pershing: 131C, 131C2, 131D, T131B, T131C	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: area reclaim, thin layer.
Weller: 132C	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: area reclaim, thin layer.
Colo: 133, 133B	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Dickinson: 175D	Good	Fair: excess fines	Unsuited	Fair: slope.
Gara: 179D, 179D2	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
179E, 179E2, 179F	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Adair: 192C, 192C2, 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, C220	Poor: frost action	Unsuited	Unsuited	Good.
Clarinda: 222C, 222C2, 222D, 222D2	Poor: shrink-swell, wetness, low strength.	Unsuited	Unsuited	Poor: area reclaim, too clayey.
Wabash: 248	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness, too clayey.
Humeston: 269	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Poor: area reclaim.
Olmitz: 273B	Poor: low strength	Unsuited	Unsuited	Good.
Haig: 362	Poor: shrink-swell, wetness, low strength.	Unsuited	Unsuited	Poor: wetness.
Grundy: 364B	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Fair: thin layer.
Macksburg: 368, 368B	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Good.
Winterset: 369	Poor: shrink-swell, wetness, low strength.	Unsuited	Unsuited	Poor: wetness.

TABLE 6.—*Construction materials*—Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
Sharpsburg:				
370B, 370C, 370C2	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
370D	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: slope, thin layer.
Nira:				
[1] 371C:				
Nira part	Poor: frost action, low strength, shrink-swell.	Unsuited	Unsuited	Fair: thin layer.
Sharpsburg part	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
[1] 371C2:				
Nira part	Poor: frost action, low strength, shrink-swell.	Unsuited	Unsuited	Fair: thin layer.
Sharpsburg part	Poor: shrink-swell, low strength.	Unsuited	Unsuited	Fair: thin layer.
Keswick:				
425C	Poor: low strength	Unsuited	Unsuited	Poor: area reclaim.
Caleb:				
451C2, 451D2	Fair: area reclaim	Unsuited	Unsuited	Poor: area reclaim.
451E2	Fair: area reclaim	Unsuited	Unsuited	Poor: area reclaim, slope.
Lineville:				
452C	Poor: low strength, frost action.	Unsuited	Unsuited	Poor: area reclaim.
Mystic:				
592C2, 592D2	Poor: low strength	Unsuited	Unsuited	Poor: area reclaim.
Armstrong:				
792C, 792C2, 792D2	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Poor: area reclaim.
Lamoni:				
822C, 822C2, 822D, 822D2	Poor: low strength, shrink-swell.	Unsuited	Unsuited	Poor: area reclaim.
Gara:				
[1] 993D2:				
Gara part	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
Armstrong part	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Poor: area reclaim.
[1] 993E2:				
Gara part	Poor: low strength	Unsuited	Unsuited	Poor: slope.
Armstrong part	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	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 of the whole mapping unit.

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 6 provide specific information about the nature of each horizon. This information can help determine the suitability of each horizon for roadfill.

Soils rated *good* are coarse grained. They have low shrink-swell potential, low potential frost action, 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 moderate shrink-swell potential, moderately 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 take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, reaction, 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 plantlife. Also considered is the damage that can result at the area from which the topsoil is taken.

The ease of excavation is influenced by the thickness of suitable material, wetness, slope, and amount of stones. The ability of the soil to support plantlife is determined by texture, structure, and the amount of soluble salts or toxic substances. 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.

Soils rated *good* have at least 16 inches of friable loamy material at their surface. They are free of stones and cobbles, are low in content of gravel, and have gentle slopes. They are low in soluble salts that can limit or prevent 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 soils 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 and very firm clayey soils; soils with suitable layers less than 8 inches thick; soils having 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. The absorption and retention of moisture and nutrients for plant growth are greatly increased by organic matter.

Water management

Many soil properties and site features that affect water management practices 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 best suited to 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. Large stones and organic matter in a soil downgrade the suitability of a soil for use in embankments, dikes, and levees.

Drainage of soil is affected by such soil properties as permeability; texture; depth to bedrock, hardpan, or other layers that affect the 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 water erosion and soil blowing, texture, presence of salts and alkali, depth of root zone, rate of water intake at the surface, permeability of the soil 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, hardpan, or other unfavorable material; large stones; permeability; ease of establishing vegetation; and resistance to water 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, wetness, 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

TABLE 7.—*Water management*

[Some 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.
Colo:						
[1] 11B:						
Colo part	Favorable	Compressible, low strength, hard to pack.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
Ely part	Favorable	Low strength, compressible, shrink-swell.	Favorable	Favorable	Wetness	Favorable.
Nodaway:						
[1] 13B:						
Nodaway part	Seepage	Low strength	Floods	Floods	Not needed	Not needed.
Vesser part	Favorable	Low strength, shrink-swell.	Floods	Floods	Erodes easily, wetness.	Erodes easily, wetness.
Arispe:						
23C	Favorable	Compressible, shrink-swell.	Slope	Slope, slow intake.	Erodes easily	Erodes easily.
Shelby:						
24C, 24C2	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Favorable	Erodes easily, slope.
24D, 24D2, 24D3, 24E, 24E2, 24F2	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope. erodes easily.	Erodes easily, slope.	Erodes easily, slope.
Vesser:						
51	Favorable	Low strength, shrink-swell.	Floods	Floods	Erodes easily, wetness.	Erodes easily, wetness.
Lindley:						
65E, 65F	Slope	Favorable	Not needed	Slope	Slope, percs slowly, erodes easily.	Erodes easily, percs slowly, slope.
Clearfield:						
69C	Favorable	Compressible, low strength, shrink-swell.	Favorable	Wetness, percs slowly.	Wetness, percs slowly.	Wetness, percs slowly.
Ladoga:						
76B, 76C, 76C2, 76D, T76B, T76C	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Adair:						
[1] 93D:						
Adair part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, percs slowly, slow intake.	Complex slope.	Percs slowly.
Shelby part	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
[1] 93D2:						
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
Shelby part	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
[1] 93E2: Adair part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, percs slowly, slow intake.	Complex slope.	Percs slowly.
Shelby part	Slope	Low strength, shrink-swell.	Not needed	Slow intake, slope, erodes easily.	Erodes easily. slope.	Erodes easily, slope.
Mystic: [1] 94D2: Mystic part	Slope, seepage.	Low strength	Percs slowly, slope.	Slow intake, slope.	Slope, complex slope, wetness.	Erodes easily, percs slowly.
Caleb part	Slope	Unstable fill	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.
Sperry: 122	Favorable	Compressible, low strength, shrink-swell.	Percs slowly, poor outlets, wetness.	Percs slowly, slow intake, wetness.	Not needed	Not needed.
Belinda: T130	Not needed	Compressible, low strength, shrink-swell.	Percs slowly	Wetness, slow intake.	Not needed	Not needed.
Pershing: 131C, 131C2, 131D, T131B, T131C	Favorable	Compressible, low strength, shrink-swell.	Percs slowly, slope.	Wetness, slow intake.	Percs slowly	Favorable.
Weller: 132C	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily, slow intake.	Percs slowly	Percs slowly, erodes easily.
Colo: 133, 133B	Favorable	Compressible, low strength, hard to pack.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
Dickinson: 175D	Seepage	Seepage, piping.	Not needed	Soil blowing, droughty, fast intake.	Too sandy, soil blowing, complex slope.	Droughty.
Gara: 179D, 179D2, 179E, 179E2, 179F	Slope	Low strength, shrink-swell.	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.
Adair: 192C, 192C2, 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, C220	Seepage	Low strength	Floods	Floods	Not needed	Not needed.

TABLE 7.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Clarinda:						
222C, 222C2, 222D, 222D2	Slope	Unstable fill, low strength, shrink-swell.	Percs slowly, slope, wetness.	Slow intake, erodes easily, percs slowly.	Erodes easily, percs slowly, slope.	Erodes easily, percs slowly.
Wabash:						
248	Favorable	Shrink-swell, compressible, low strength.	Floods, percs slowly, wetness.	Slow intake, wetness, floods.	Percs slowly, wetness.	Percs slowly, wetness.
Humeston:						
269	Favorable	Low strength, shrink-swell.	Percs slowly, wetness.	Slow intake	Percs slowly, wetness.	Percs slowly, wetness.
Olmitz:						
273B	Favorable	Favorable	Not needed	Favorable	Erodes easily	Erodes easily.
Haig:						
362	Favorable	Compressible, low strength, shrink-swell.	Percs slowly	Wetness	Not needed	Not needed.
Grundy:						
364B	Favorable	Low strength, shrink-swell.	Percs slowly, wetness.	Slow intake, percs slowly.	Percs slowly, wetness.	Percs slowly, wetness.
Macksburg:						
368, 368B	Favorable	Compressible, low strength, shrink-swell.	Favorable	Wetness	Favorable	Favorable.
Winterset:						
369	Favorable	Compressible, low strength, shrink-swell.	Percs slowly	Wetness, percs slowly, slow intake.	Not needed	Not needed.
Sharpsburg:						
370B, 370C, 370C2, 370D	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Nira:						
[1]371C:						
Nira part	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Sharpsburg part	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
[1]371C2:						
Nira part	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Sharpsburg part	Favorable	Compressible, low strength, shrink-swell.	Not needed	Erodes easily	Favorable	Favorable.
Keswick:						
425C	Slope	Shrink-swell, erodes easily, low strength.	Percs slowly	Erodes easily, slope.	Percs slowly	Erodes easily, percs slowly, slope.
Caleb:						
451C2, 451D2, 451E2	Slope	Unstable fill	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.

TABLE 7.—*Water management*—Continued

Soil name and map symbol	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
Lineville:						
452C	Favorable	Shrink-swell, low strength.	Percs slowly	Slow intake	Erodes easily	Erodes easily.
Mystic:						
592C2, 592D2	Slope, seepage.	Low strength	Percs slowly, slope.	Slow intake, slope.	Slope, complex slope, wetness.	Erodes easily, percs slowly.
Armstrong:						
792C, 792C2, 792D2	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, slope.	Erodes easily, percs slowly.	Erodes easily, percs slowly.
Lamoni:						
822C, 822C2, 822D, 822D2	Slope	Shrink-swell, erodes easily, low strength.	Percs slowly, slope.	Erodes easily, slope.	Erodes easily, percs slowly.	Erodes easily, percs slowly.
Gara:						
[1] 993D2:						
Gara part	Slope	Low strength, shrink-swell.	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.
Armstrong part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, slope.	Erodes easily, percs slowly.	Erodes easily, percs slowly.
[1] 993E2:						
Gara part	Slope	Low strength, shrink-swell.	Not needed	Erodes easily, slope.	Erodes easily, slope.	Erodes easily, slope.
Armstrong part	Slope	Shrink-swell, erodes easily.	Percs slowly	Erodes easily, slope.	Erodes easily, percs slowly.	Erodes easily, percs slowly.

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

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 soil 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.

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

TABLE 8.—*Recreational development*

[Some 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.
Colo:				
[1] 11B:				
Colo part	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Ely part	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey, slope.	Moderate: wetness, too clayey.
Nodaway:				
[1] 13B:				
Nodaway part	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Vesser part	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.
Arispe:				
23C	Moderate: percs slowly.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
Shelby:				
24C, 24C2	Moderate: percs slowly.	Slight	Severe: slope	Slight.
24D, 24D2, 24D3	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
24E, 24E2, 24F2	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Vesser:				
51	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.
Lindley:				
65E, 65F	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
Clearfield:				
69C	Severe: wetness, percs slowly.	Moderate: too clayey.	Severe: percs slowly, slope.	Moderate: too clayey.
Ladoga:				
76B, T76B	Moderate: percs slowly.	Slight	Moderate: percs slowly, slope.	Slight.
76C, 76C2, T76C	Moderate: percs slowly.	Slight	Severe: slope	Slight.
76D	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
Adair:				
[1] 93D:				
Adair part	Moderate: percs slowly, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
Shelby part	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
[1] 93D2:				
Adair part	Moderate: percs slowly, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
Shelby part	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.

TABLE 8.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
[1] 93E2: Adair part	Severe: slope	Severe: slope	Severe: slope	Moderate: wetness.
Shelby part	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Mystic: [1] 94D2: Mystic part	Moderate: percs slowly, wetness, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
Caleb part	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
Sperry: 122	Severe: percs slowly, wetness.	Severe: wetness	Severe: percs slowly, wetness.	Severe: wetness.
Belinda: T130	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Pershing: 131C, 131C2, 131D, T131C	Moderate: percs slowly, wetness.	Moderate: wetness	Severe: slope	Moderate: wetness.
T131B	Moderate: percs slowly, wetness.	Moderate: wetness	Moderate: wetness, percs slowly.	Moderate: wetness.
Weller: 132C	Moderate: wetness, percs slowly.	Slight	Severe: slope	Slight.
Colo: 133, 133B	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Dickinson: 175D	Moderate: slope	Moderate: slope	Severe: slope	Slight.
Gara: 179D, 179D2	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
179E, 179E2, 179F	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Adair: 192C, 192C2	Moderate: percs slowly.	Moderate: wetness	Severe: slope	Moderate: wetness.
192D2	Moderate: percs slowly, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
Kennebec: 212	Severe: floods	Moderate: floods	Moderate: floods	Slight.
Nodaway: 220, C220	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
Clarinda: 222C, 222C2, 222D, 222D2	Severe: percs slowly, wetness.	Severe: wetness	Severe: wetness, percs slowly.	Severe: wetness.
Wabash: 248	Severe: floods, wetness, percs slowly.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, percs slowly.	Severe: wetness, too clayey.
Humeston: 269	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Olmitz: 273B	Slight	Slight	Moderate: slope	Slight.

TABLE 8.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Haig:				
362	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Grundy:				
364B	Moderate: percs slowly, wetness.	Moderate: wetness	Moderate: percs slowly, wetness.	Moderate: wetness.
Macksburg:				
368	Moderate: wetness, too clayey, percs slowly.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
368B	Moderate: wetness, too clayey, percs slowly.	Moderate: wetness, too clayey.	Moderate: wetness, slope.	Moderate: wetness, too clayey.
Winterset:				
369	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Sharpsburg:				
370B	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Moderate: too clayey, percs slowly.	Moderate: too clayey.
370C, 370C2	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
370D	Moderate: percs slowly, too clayey.	Moderate: slope, too clayey.	Severe: slope	Moderate: too clayey.
Nira:				
[1] 371C:				
Nira part	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
Sharpsburg part	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
[1] 371C2:				
Nira part	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
Sharpsburg part	Moderate: percs slowly, too clayey.	Moderate: too clayey.	Severe: slope	Moderate: too clayey.
Keswick:				
425C	Moderate: percs slowly, wetness.	Moderate: wetness	Severe: slope	Moderate: wetness.
Caleb:				
451C2	Moderate: percs slowly.	Slight	Severe: slope	Slight.
451D2	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
451E2	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Lineville:				
452C	Moderate: percs slowly, wetness.	Moderate: wetness	Severe: slope	Moderate: wetness.
Mystic:				
592C2	Moderate: percs slowly, wetness.	Moderate: wetness	Severe: slope	Moderate: wetness.
592D2	Moderate: percs slowly, wetness, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
Armstrong:				
792C, 792C2	Moderate: percs slowly, wetness.	Moderate: wetness	Severe: slope	Moderate: wetness.
792D2	Moderate: percs slowly, wetness, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.

TABLE 8.—*Recreational development*—Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails
Lamoni:				
822C, 822C2	Severe: percs slowly	Moderate: wetness, too clayey.	Severe: percs slowly, slope.	Moderate: wetness, too clayey.
822D, 822D2	Severe: percs slowly	Moderate: slope, too clayey.	Severe: percs slowly, slope.	Moderate: wetness, too clayey.
Gara:				
993D2:				
Gara part	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
Armstrong part	Moderate: percs slowly, wetness, slope.	Moderate: wetness, slope.	Severe: slope	Moderate: wetness.
[1]993E2:				
Gara part	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Armstrong part	Severe: slope	Severe: slope	Severe: slope	Moderate: wetness, 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 of the whole mapping unit.

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, or 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 planning for parks, wildlife refuges, nature study areas, and other developments for wildlife; selecting areas that are suitable for wildlife; selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat; and 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 must be intensive. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife 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. 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. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. 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. Examples of grasses and legumes are fescue, orchardgrass, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds, that provide food and cover for wildlife. 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

TABLE 9.—*Wildlife habitat potentials*

[See text for definitions of "good," "fair," "poor," and "very poor"]

Soil name and map symbol	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Judson:										
8B	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Colo:										
[1] 11B:										
Colo part	Good	Fair	Good	Fair	Poor	Fair	Very poor.	Fair	Fair	Poor.
Ely part	Fair	Good	Good	Good	Good	Fair	Very poor.	Good	Good	Poor.
Nodaway:										
[1] 13B:										
Nodaway part	Good	Good	Good	Good	Fair	Fair	Poor	Fair	Good	Fair.
Vesser part	Good	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Arispe:										
23C	Good	Good	Good	Good	Good	Very poor.	Poor	Good	Good	Very poor.
Shelby:										
24C, 24C2, 24D, 24D2, 24D3	Fair	Good	Fair	Good	Good	Poor	Poor	Fair	Good	Poor.
24E, 24E2, 24F2	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
Vesser:										
51	Good	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Lindley:										
65E, 65F	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Clearfield:										
69C	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Ladoga:										
76B, T76B	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
76C, 76C2, 76D, T76C	Fair	Good	Fair	Good	Good	Very poor.	Poor	Fair	Good	Very poor.
Adair:										
[1] 93D:										
Adair part	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
Shelby part	Fair	Good	Fair	Good	Good	Poor	Poor	Fair	Good	Poor.
[1] 93D2:										
Adair part	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
Shelby part	Fair	Good	Fair	Good	Good	Poor	Poor	Fair	Good	Poor.
[1] 93E2:										
Adair part	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
Shelby part	Poor	Fair	Fair	Fair	Fair	Poor	Poor	Fair	Fair	Poor.
Mystic:										
[1] 94D2:										
Mystic part	Fair	Good	Fair	Good	Fair	Poor	Poor	Fair	Good	Poor.
Caleb part	Fair	Good	Fair	Good	Fair	Poor	Poor	Fair	Good	Poor.
Sperry:										
122	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Belinda:										
T130	Good	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Pershing:										
131C, 131C2, T131C, 131D.	Fair	Fair	Fair	Fair	Fair	Very poor.	Poor	Fair	Fair	Very poor.
T131B	Good	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.

TABLE 9.—*Wildlife habitat potentials*—Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Weller: 132C	Fair	Fair	Fair	Fair	Fair	Very poor.	Poor	Fair	Fair	Very poor.
Colo: 133	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
133B	Good	Fair	Good	Fair	Poor	Fair	Very poor.	Fair	Fair	Poor.
Dickinson: 175D	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
Gara: 179D, 179D2	Fair	Good	Fair	Good	Good	Very poor.	Poor	Fair	Good	Poor.
179E, 179E2, 179F	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
Adair: 192C, 192C2, 192D2	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
Kennebec: 212	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Nodaway: 220, C220	Good	Good	Good	Good	Fair	Fair	Poor	Fair	Good	Fair.
Clarinda: 222C, 222C2, 222D, 222D2	Poor	Fair	Poor	Fair	Poor	Poor	Poor	Fair	Fair	Poor.
Wabash: 248	Poor	Poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
Humeston: 269	Good	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Olmitz: 273B	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
Haig: 362	Good	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Grundy: 364B	Fair	Good	Fair	Good	Good	Fair	Fair	Fair	Good	Fair.
Macksburg: 368, 368B	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
Winterset: 369	Good	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
Sharpsburg: 370B	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
370C, 370C2, 370D	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
Nira: [1]371C:										
Nira part	Fair	Good	Fair	Good	Good	Very poor.	Poor	Fair	Good	Very poor.
Sharpsburg part	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
[1]371C2:										
Nira part	Fair	Good	Fair	Good	Good	Very poor.	Poor	Fair	Good	Very poor.
Sharpsburg part	Fair	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.

TABLE 9.—*Wildlife habitat potentials*—Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
Keswick:										
425C	Fair	Good	Fair	Good	Fair	Poor	Poor	Fair	Good	Poor.
Caleb:										
451C2, 451D2	Fair	Good	Fair	Good	Fair	Poor	Poor	Fair	Good	Poor.
451E2	Poor	Good	Fair	Good	Fair	Very poor.	Very poor.	Poor	Good	Very poor.
Lineville:										
452C	Fair	Good	Fair	Good	Fair	Poor	Poor	Fair	Good	Poor.
Mystic:										
592C2, 592D2	Fair	Good	Fair	Good	Fair	Poor	Poor	Fair	Good	Poor.
Armstrong:										
792C, 792C2, 792D2	Fair	Good	Fair	Good	Fair	Very poor.	Poor	Fair	Good	Very poor.
Lamoni:										
822C, 822C2, 822D, 822D2	Fair	Good	Fair	Fair	Fair	Poor	Poor	Good	Fair	Poor.
Gara:										
[1] 993D2:										
Gara part	Fair	Good	Fair	Good	Good	Very poor.	Poor	Fair	Good	Poor.
Armstrong part	Fair	Good	Fair	Good	Fair	Very poor.	Poor	Fair	Good	Very poor.
[1] 993E2:										
Gara part	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
Armstrong part	Poor	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.

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

considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of native plants are oak, poplar, cherry, apple, hawthorn, dogwood, hickory, and elderberry. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

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. Soil properties that have a major effect on the growth of coniferous plants are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

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. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, wildrice, saltgrass, and cordgrass and rushes, sedges, and reeds.

Shallow water areas are bodies of water that have an average depth of less than 5 feet and that 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. 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. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

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, cottontail rabbit, and red fox.

Woodland habitat consists of areas of hardwoods or conifers, or a mixture of both, and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, ruffed grouse, woodcock, thrushes, woodpeckers, squirrels, gray fox, raccoon, deer, and bear.

Wetland habitat consists of open, marshy or swampy, shallow water areas where water-tolerant plants grow. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, 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 typical 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 the natural pattern of cracks and pores in the undisturbed soil; and the consistence of the soil material in place under the existing soil moisture conditions. They record the depth of plant roots, determine the pH or reaction of the soil, and identify any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to determine all major properties of 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 soil series not tested are available from nearby survey 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.

Most soils have, within the upper 5 or 6 feet, horizons of contrasting properties. 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 in each horizon is given for each soil series in the section "Soil series and morphology."

Texture is described in table 10 in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in 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 are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified Soil Classification System (Unified) (*2*)[1] and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO) (*1*).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter, 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 rock fragments more than 3 inches in diameter is estimated for each major horizon. These estimates are determined mainly 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 AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior. Range in liquid limit and plasticity index are esti-

[1] Italic numbers in parentheses refer to References, p. 117.

mated 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.

In some surveys, the estimates are rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterburg limits extend a marginal amount across classification boundaries (1 or 2 percent), the classification in the marginal zone is omitted.

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 typical pedon 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 is 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 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:

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.

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.

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.

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.

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.

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.

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.

Silty clay loams that are less than 35 percent clay

TABLE 10.—*Engineering properties*

[The symbol > means greater than. Absence

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO
	In			
Judson:				
8B	0–28	Silty clay loam	OL, CL, CL–ML, ML	A–6, A–7, A–4
	28–60	Silty clay loam, silt loam	CL, CL–ML, ML	A–6, A–7, A–4
Colo:				
[1] 11B:				
Colo part	0–41	Silty clay loam	CL, CH	A–7
	41–60	Silty clay loam	CL, CH	A–7
Ely part	0–32	Silty clay loam	CL, OL, CL–ML	A–7, A–6
	32–60	Silty clay loam	CL	A–7, A–6
Nodaway:				
[1] 13B:				
Nodaway part	0–80	Silt loam	CL, CL–ML	A–4, A–6
Vesser part	0–10	Silt loam	CL	A–6
	10–25	Silt loam	CL	A–6
	25–70	Silty clay loam	CL, CH	A–6, A–7
Arispe:				
23C	0–7	Silty clay loam	CL, CH	A–7
	7–40	Silty clay loam	CH, CL	A–7
	40–60	Silty clay loam	CL	A–7
Shelby:				
24C, 24C2, 24D, 24D2, 24D3, 24E, 24E2, 24F2	0–15	Clay loam	CL	A–6
	15–38	Clay loam	CL	A–6, A–7
	38–65	Clay loam	CL	A–6, A–7
Vesser:				
51	0–10	Silt loam	CL	A–6
	10–25	Silt loam	CL	A–6
	25–70	Silty clay loam	CL, CH	A–6, A–7
Lindley:				
65E, 65F	0–10	Loam	CL–ML, CL	A–4, A–6
	10–60	Clay loam, loam	CL	A–6, A–7
Clearfield:				
69C	0–13	Silty clay loam	CH, OH, CL, OL	A–7
	13–48	Silty clay loam	CH, MH	A–7
	48–60	Silty clay, silty clay loam	CH, MH	A–7
Ladoga:				
76B, 76C, 76C2, 76D, T76B, T76C	0–11	Silt loam	CL, CL–ML	A–6, A–4
	11–65	Silty clay loam	CL, CH	A–7
Adair:				
[1] 93D:				
Adair part	0–16	Clay loam	CL	A–6
	16–35	Silty clay, clay, clay loam	CL, CH	A–7
	35–60	Clay loam	CL	A–6, A–7
Shelby part	0–15	Clay loam	CL	A–6
	15–38	Clay loam	CL	A–6, A–7
	38–65	Clay loam	CL	A–6, A–7
[1] 93D2:				
Adair part	0–16	Clay loam	CL	A–6
	16–35	Silty clay, clay, clay loam	CL, CH	A–7
	35–60	Clay loam	CL	A–6, A–7
Shelby part	0–15	Clay loam	CL	A–6
	15–38	Clay loam	CL	A–6, A–7
	38–65	Clay loam	CL	A–6, A–7

and classifications

of an entry means 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	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	30–55	5–25
0	100	100	95–100	95–100	35–50	11–25
0	100	95–100	95–100	90–100	25–35	5–15
0	100	100	98–100	95–100	30–40	11–20
0	100	100	98–100	95–100	30–40	11–20
0	100	100	98–100	95–100	35–55	15–25
0	100	100	100	95–100	41–55	20–30
0	100	100	100	95–100	45–60	25–35
0	100	100	100	95–100	41–50	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	100	100	98–100	95–100	30–40	11–20
0	100	100	98–100	95–100	30–40	11–20
0	100	100	98–100	95–100	35–55	15–25
0	95–100	90–100	85–95	50–65	15–30	5–15
0	95–100	90–100	85–95	55–75	30–45	15–25
0	100	100	100	95–100	45–55	20–30
0	100	100	100	95–100	50–60	25–35
0	100	100	95–100	80–90	55–70	35–45
0	100	100	100	95–100	25–40	5–15
0	100	100	100	95–100	41–55	25–35
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
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

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
[1] 93E2:				
Adair part	0–16	Clay loam	CL	A-6
	16–35	Silty clay, clay, clay loam	CL, CH	A-7
	35–60	Clay loam	CL	A-6, A-7
Shelby part	0–15	Clay loam	CL	A-6
	15–38	Clay loam	CL	A-6, A-7
	38–65	Clay loam	CL	A-6, A-7
Mystic:				
[1] 94D2:				
Mystic part	0–12	Silt loam	CL, CL–ML, ML	A-4, A-6
	12–54	Clay loam, clay, silty clay	CL	A-6, A-7
	54–62	Sandy clay loam	SC, CL, SM–SC, CL–ML	A-6, A-4
Caleb part	0–14	Loam	CL	A-6
	14–32	Clay loam, loam, sandy clay loam	CL, CH	A-6, A-7
	32–72	Sandy clay loam, sandy loam	SC, CL, SM–SC, CL–ML	A-4, A-6
Sperry:				
122	0–20	Silt loam	ML, CL	A-6
	20–51	Silty clay loam, silty clay	CH	A-7-6
	51–72	Silty clay loam	CL	A-7-6
Belinda:				
T130	0–7	Silt loam	CL, CL–ML	A-4, A-6
	7–18	Silt loam	CL–ML, CL	A-4
	18–43	Silty clay	CH	A-7
	43–80	Silty clay loam	CH	A-7
Pershing:				
131C, 131C2, 131D, T131B, T131C	0–10	Silt loam	CL	A-6
	10–34	Silty clay loam, silty clay	CH	A-7
	34–61	Silty clay loam	CH, CL	A-7
Weller:				
132C	0–12	Silt loam	ML, CL	A-6, A-4
	12–41	Silty clay loam, silty clay	CH	A-7
	41–63	Silty clay loam	CH, CL	A-7
Colo:				
133, 133B	0–41	Silty clay loam	CL, CH	A-7
	41–60	Silty clay loam	CL, CH	A-7
Dickinson:				
175D	0–23	Fine sandy loam	SM, SC	A-4, A-2
	23–60	Loamy sand	SM, SP	A-2
	50–60	Sand	SP, SM	A-3, A-2
Gara:				
179D, 179D2, 179E, 179E2, 179F	0–12	Loam	CL, CL–ML	A-4, A-6
	12–40	Clay loam	CL	A-6
	40–60	Loam, clay loam	CL	A-6
Adair:				
192C, 192C2, 192D2	0–16	Clay loam	CL	A-6
	16–35	Silty clay, clay, clay loam	CL, CH	A-7
	35–60	Clay loam	CL	A-6, A-7
Kennebec:				
212	0–30	Silt loam	CL, ML, CL–ML	A-6, A-7, A-4
	30–60	Silt loam, silty clay loam	CL	A-6, A-7, A-4
Nodaway:				
220, C220	0–80	Silt loam	CL, CL–ML	A-4, A-6

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
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	100	95–100	95–100	65–90	30–40	5–20
0	100	95–100	95–100	65–80	35–45	20–30
0	100	95–100	90–95	40–65	25–35	5–20
0	90–100	80–100	70–90	60–80	30–40	10–20
0	85–100	80–100	60–80	50–75	35–55	15–30
0	85–100	80–100	50–75	35–60	20–35	5–15
0	100	100	100	95–100	30–40	11–20
0	100	100	100	95–100	50–60	20–30
0	100	100	100	95–100	41–55	15–25
0	100	100	100	95–100	30–40	5–15
0	100	100	100	95–100	25–35	5–10
0	100	100	100	95–100	55–70	30–40
0	100	100	100	95–100	50–65	25–35
0	100	100	100	95–100	30–40	11–20
0	100	100	100	95–100	50–65	30–40
0	100	100	100	95–100	45–55	25–35
0	100	100	100	95–100	30–40	5–15
0	100	100	100	95–100	50–65	30–40
0	100	100	100	95–100	45–55	20–30
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	85–95	35–50	15–30	NP–10
0	100	100	80–95	5–20	10–30	NP–5
0	100	100	70–90	5–20	------	NP
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

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Clarinda:				
222C, 222C2, 222D, 222D2	0–7	Silty clay loam	CL	A-7
	7–33	Silty clay, clay	CH	A-7
	33–65	Clay	CH	A-7
Wabash:				
248	0–17	Silty clay loam	CL, CH	A-6, A-7
	17–72	Silty clay, clay	CH	A-7
Humeston:				
269	0–13	Silty clay loam	CL, CL–ML	A-6, A-4
	13–26	Silt loam	CL, CL–ML	A-7, A-6, A-4
	26–63	Silty clay loam, silty clay	CH, CL	A-7
Olmitz:				
273B	0–33	Loam	CL	A-6
	33–63	Clay loam	CL	A-6, A-7
Haig:				
362	0–7	Silty clay loam	CL, OL	A-6, A-7
	7–24	Silty clay loam, silty clay	CL, CH	A-7
	24–44	Silty clay	CH	A-7
	44–65	Silty clay loam	CL, CH	A-7, A-6
Grundy:				
364B	0–11	Silty clay loam	CL, ML	A-6, A-7, A-4
	11–24	Silty clay loam, silty clay	CH, CL	A-7
	24–37	Silty clay, silty clay loam	CH	A-7
	37–60	Silty clay loam	CH, CL	A-7
Macksburg:				
368, 368B	0–22	Silty clay loam	ML, OL, CL	A-7
	22–43	Silty clay loam, silty clay	CH	A-7
	43–67	Silty clay loam	CL	A-7
Winterset:				
369	0–18	Silty clay loam	CL, OL	A-7
	18–42	Silty clay, silty clay loam	CH	A-7
	42–75	Silty clay loam	CL, CH	A-7
Sharpsburg:				
370B, 370C, 370C2, 370D	0–13	Silty clay loam	OL, CL, CH, OH	A-7, A-6
	13–40	Silty clay loam, silty clay	CH, CL	A-7, A-6
	40–62	Silty clay loam	CL	A-7, A-6
Nira:				
[1] 371C:				
Nira part	0–13	Silty clay loam	CL, OL	A-7
	13–30	Silty clay loam	CL	A-7
	30–60	Silty clay loam	CL	A-6, A-7
Sharpsburg part	0–13	Silty clay loam	OL, CL, CH, OH	A-7, A-6
	13–40	Silty clay loam, silty clay	CH, CL	A-7, A-6
	40–62	Silty clay loam	CL	A-7, A-6
[1] 371C2:				
Nira part	0–13	Silty clay loam	CL, OL	A-7
	13–30	Silty clay loam	CL	A-7
	30–60	Silty clay loam	CL	A-6, A-7
Sharpsburg part	0–13	Silty clay loam	OL, CL, CH, OH	A-7, A-6
	13–40	Silty clay loam, silty clay	CH, CL	A-7, A-6
	40–62	Silty clay loam	CL	A-7, A-6
Keswick:				
425C	0–11	Loam	CL, CL–ML	A-6, A-4
	11–35	Clay loam, clay	CH, MH	A-7
	35–64	Clay loam, sandy clay loam	CL, SC	A-6

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	95–100	90–100	85–100	40–50	20–30
0	100	95–100	85–100	80–100	55–70	30–40
0	95–100	95–100	80–95	75–90	50–60	25–35
0	100	100	100	95–100	30–55	12–35
0	100	100	100	95–100	52–78	30–55
0	100	100	95–100	95–100	25–40	5–20
0	100	100	95–100	95–100	25–45	5–20
0	100	100	95–100	95–100	45–55	25–35
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	95–100	90–100	35–45	10–20
0	100	100	95–100	90–100	40–55	20–30
0	100	100	95–100	90–100	50–65	30–40
0	100	100	95–100	90–100	35–60	20–30
0	100	100	95–100	90–100	30–45	5–25
0	100	100	95–100	95–100	45–55	30–40
0	100	100	95–100	95–100	50–70	30–45
0	100	100	95–100	95–100	45–55	30–40
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
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	100	100	95–100	41–50	15–25
0	100	100	100	95–100	41–50	20–30
0	100	100	100	95–100	35–45	15–25
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	100	100	95–100	41–50	15–25
0	100	100	100	95–100	41–50	20–30
0	100	100	100	95–100	35–45	15–25
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	95–100	80–100	75–90	60–80	20–30	5–15
0	95–100	80–100	70–90	55–80	50–60	20–30
0	95–100	80–100	65–85	40–70	35–40	15–25

TABLE 10.—*Engineering properties*

Soil name and map symbol	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
Caleb:				
451C2, 451D2, 451E2	0–14	Loam	CL	A–6
	14–32	Clay loam, loam, sandy clay loam	CL, CH	A–6, A–7
	32–72	Sandy clay loam, sandy loam	SC, CL, SM–SC, CL–ML	A–4, A–6
Lineville:				
452C	0–11	Silt loam	ML, CL	A–6, A–7
	11–28	Silty clay loam	CL, CH	A–7
	23–58	Clay loam, loam	CL	A–6, A–7
	58–72	Clay loam, clay	CH	A–7
Mystic:				
592C2, 592D2	0–12	Silt loam	CL, CL–ML, ML	A–4, A–6
	12–54	Clay loam, clay, silty clay	CL	A–6, A–7
	54–62	Sandy clay loam	SC, CL, SM–SC, CL–ML	A–6, A–4
Armstrong:				
792C, 792C2, 792D2	0–10	Loam	CL, CL–ML	A–6, A–4
	10–31	Clay loam, clay, silty clay loam	CL, CH	A–7
	31–60	Clay loam	CL	A–6
Lamoni:				
822C, 822C2, 822D, 822D2	0–12	Silty clay loam	CL	A–6, A–7
	12–31	Clay loam, clay	CH	A–7
	31–71	Clay loam	CL	A–6, A–7
Gara:				
[1] 993D2:				
Gara part	0–12	Loam	CL, CL–ML	A–4, A–6
	12–40	Clay loam	CL	A–6
	40–60	Loam, clay loam	CL	A–6
Armstrong part	0–10	Loam	CL, CL–ML	A–6, A–4
	10–31	Clay loam, clay, silty clay loam	CL, CH	A–7
	31–60	Clay loam	CL	A–6
[1] 993E2:				
Gara part	0–12	Loam	CL, CL–ML	A–4, A–6
	12–40	Clay loam	CL	A–6
	40–60	Loam, clay loam	CL	A–6
Armstrong part	0–10	Loam	CL, CL–ML	A–6, A–4
	10–31	Clay loam, clay, silty clay loam	CL, CH	A–7
	31–60	Clay loam	CL	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
[2] Nonplastic.

and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible, and crops can easily be grown.

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.

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0 0 0	90–100 85–100 85–100	80–100 80–100 80–100	70–90 60–80 50–75	60–80 50–75 35–60	30–40 35–55 20–35	10–20 15–30 5–15
0 0 0 0	100 100 95–100 95–100	100 100 80–100 80–100	95–100 95–100 75–95 70–90	95–100 95–100 65–90 55–80	35–45 45–55 35–50 55–60	11–15 25–35 20–35 20–35
0 0 0	100 100 100	95–100 95–100 95–100	95–100 95–100 90–95	65–90 65–80 40–65	30–40 35–45 25–35	5–20 20–30 5–20
0 0 0	95–100 95–100 95–100	80–95 80–95 80–95	75–90 70–90 70–90	55–80 55–80 55–80	20–40 45–60 35–40	5–20 20–30 15–25
0 0 0	95–100 95–100 95–100	95–100 95–100 95–100	80–95 90–100 70–90	70–95 85–100 55–85	35–45 50–60 35–50	15–25 25–35 15–30
0 0 0	85–95 85–95 85–95	80–90 80–90 80–90	70–80 70–85 70–85	55–70 55–75 55–75	20–30 30–40 35–45	5–15 15–25 15–25
0 0 0	95–100 95–100 95–100	80–95 80–95 80–95	75–90 70–90 70–90	55–80 55–80 55–80	20–40 45–60 35–40	5–20 20–30 15–25
0 0 0	85–95 85–95 85–95	80–90 80–90 80–90	70–80 70–85 70–85	55–70 55–75 55–75	20–30 30–40 35–45	5–15 15–25 15–25
0 0 0	95–100 95–100 95–100	80–95 80–95 80–95	75–90 70–90 70–90	55–80 55–80 55–80	20–40 45–60 35–40	5–20 20–30 15–25

behavior of the whole mapping unit.

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 depth; and absence of distinctive soil horizons that form in soils of the area that are not subject to

TABLE 11.—*Physical and chemical*

[Dashes indicate data were not available. The symbol < means less than. The erosion tolerance

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
Judson:				
8B	0–28	0.6–2.0	0.21–0.23	6.1–7.3
	28–60	0.6–2.0	0.21–0.23	6.1–7.8
Colo:				
[1] 11B:				
Colo part	0–41	0.2–0.6	0.21–0.23	5.6–6.5
	41–60	0.2–0.6	0.18–0.20	6.1–7.3
Ely part	0–32	0.6–2.0	0.21–0.23	5.6–6.5
	32–60	0.6–2.0	0.18–0.20	6.1–7.3
Nodaway:				
[1] 13B:				
Nodaway part	0–80	0.6–2.0	0.20–0.23	6.1–7.3
Vesser part	0–10	0.6–2.0	0.20–0.24	5.6–6.5
	10–25	0.6–2.0	0.18–0.22	5.1–6.0
	25–70	0.2–2.0	0.17–0.21	5.6–6.5
Arispe:				
23C	0–7	0.6–2.0	0.21–0.23	5.6–6.0
	7–40	0.2–0.6	0.18–0.20	5.6–7.3
	40–60	0.2–0.6	0.18–0.20	6.6–7.3
Shelby:				
24C, 24C2, 24D, 24D2, 24D3, 24E, 24E2, 24F2	0–15	0.6–2.0	0.20–0.22	5.6–6.0
	15–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–65	0.2–0.6	0.16–0.18	6.6–7.8
Vesser:				
51	0–10	0.6–2.0	0.20–0.24	5.6–6.5
	10–25	0.6–2.0	0.18–0.22	5.1–6.0
	25–70	0.2–2.0	0.17–0.21	5.6–6.5
Lindley:				
65E, 65F	0–10	0.6–2.0	0.16–0.18	4.5–6.0
	10–60	0.2–0.6	0.14–0.18	4.5–6.5
Clearfield:				
69C	0–13	0.2–0.6	0.21–0.23	5.6–7.3
	13–48	0.2–0.6	0.18–0.20	5.6–7.3
	48–60	<0.06	0.10–0.12	5.6–7.3
Ladoga:				
76B, 76C, 76C2, 76D, T76B, T76C	0–11	0.6–2.0	0.22–0.24	6.1–6.5
	11–65	0.2–0.6	0.18–0.20	5.1–6.0
Adair:				
[1] 93D:				
Adair part	0–16	0.2–0.6	0.17–0.19	5.6–6.5
	16–35	0.06–0.2	0.13–0.16	5.1–6.5
	35–60	0.2–0.6	0.14–0.16	5.6–6.5
Shelby part	0–15	0.6–2.0	0.20–0.22	5.6–6.0
	15–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–65	0.2–0.6	0.16–0.18	6.6–7.8
[1] 93D2:				
Adair part	0–16	0.2–0.6	0.17–0.19	5.6–6.5
	16–35	0.06–0.2	0.13–0.16	5.1–6.5
	35–60	0.2–0.6	0.14–0.16	5.6–6.5
Shelby part	0–15	0.6–2.0	0.20–0.22	5.6–6.0
	15–38	0.2–0.6	0.16–0.18	5.6–6.0
	38–65	0.2–0.6	0.16–0.18	6.6–7.8

properties of soils

factor (T) is for the entire profile. Absence of an entry means data were not estimated]

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Moderate	Moderate	Low	0.28	5	7
Moderate	Moderate	Low	0.43		
High	High	Moderate	---	---	7
High	High	Moderate	---		
Moderate	High	Moderate	0.32	5	7
Moderate	High	Low	0.43		
Moderate	Moderate	Low	---	---	7
Moderate	High	Moderate	0.32	5	7
Moderate	High	Moderate	0.43		
Moderate	High	Moderate	0.43		
High	High	Moderate	0.32	5	4
High	High	Moderate	0.43		
High	High	Moderate	0.43		
Moderate	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	Moderate	Moderate	0.37		
Moderate	High	Moderate	0.32	5	7
Moderate	High	Moderate	0.43		
Moderate	High	Moderate	0.43		
Low	Moderate	Moderate	0.32	5	6
Moderate	Moderate	Moderate	0.32		
High	High	Low	0.37	5	7
High	High	Low	0.37		
High	High	Low	0.37		
Low	Moderate	Low	0.32	5	6
Moderate	Moderate	Moderate	0.43		
Moderate	High	Moderate	0.32	3	6
High	High	Moderate	0.32		
Moderate	High	Moderate	0.32		
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	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	Moderate	Moderate	0.37		

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:				
Adair part	0–16 16–35 35–60	0.2–0.6 0.06–0.2 0.2–0.6	0.17–0.19 0.13–0.16 0.14–0.16	5.6–6.5 5.1–6.5 5.6–6.5
Shelby part	0–15 15–38 38–65	0.6–2.0 0.2–0.6 0.2–0.6	0.20–0.22 0.16–0.18 0.16–0.18	5.6–6.0 5.6–6.0 6.6–7.8
Mystic:				
[1] 94D2:				
Mystic part	0–12 12–54 54–62	0.6–2.0 0.06–0.2 0.6–2.0	0.22–0.24 0.15–0.19 0.16–0.18	4.5–6.0 4.5–6.5 6.1–6.5
Caleb part	0–14 14–32 32–72	0.6–2.0 0.2–0.6 0.6–2.0	0.14–0.18 0.14–0.18 0.12–0.16	4.5–6.0 4.5–6.0 6.1–6.5
Sperry: 122	0–20 20–51 51–72	0.6–2.0 <0.2 0.6–2.0	0.22–0.24 0.14–0.16 0.19–0.21	5.6–6.5 5.6–6.5 6.1–6.5
Belinda: T130	0–7 7–18 18–43 43–80	0.6–2.0 0.6–2.0 <0.06 0.06–0.6	0.22–0.24 0.20–0.22 0.12–0.14 0.18–0.20	5.6–6.5 4.5–6.0 4.5–5.5 5.1–6.0
Pershing: 131C, 131C2, 131D, T131B, T131C	0–10 10–34 34–61	0.6–2.0 0.06–0.2 0.2–0.6	0.22–0.24 0.18–0.20 0.18–0.20	4.5–6.5 5.1–6.0 5.1–6.0
Weller: 132C	0–12 12–41 41–63	0.6–2.0 0.06–0.2 0.2–0.6	0.22–0.24 0.12–0.18 0.18–0.20	4.5–6.0 4.5–6.0 5.1–6.0
Colo: 133, 133B	0–41 41–60	0.2–0.6 0.2–0.6	0.21–0.23 0.18–0.20	5.6–6.5 6.1–7.3
Dickinson: 175D	0–23 23–50 50–60	2.0–6.0 6.0–20 6.0–20	0.12–0.15 0.08–0.10 0.02–0.04	5.6–6.5 5.6–6.5 5.6–6.5
Gara: 179D, 179D2, 179E, 179E2, 179F	0–12 12–40 40–60	0.6–2.0 0.2–0.6 0.2–0.6	0.20–0.22 0.16–0.18 0.16–0.18	5.6–6.0 5.1–6.5 6.6–7.8
Adair: 192C, 192C2, 192D2	0–16 16–35 35–60	0.2–0.6 0.06–0.2 0.2–0.6	0.17–0.19 0.13–0.16 0.14–0.16	5.6–6.5 5.1–6.5 5.6–6.5
Kennebec: 212	0–30 30–60	0.6–2.0 0.6–2.0	0.22–0.24 0.20–0.22	5.6–6.5 6.1–7.3
Nodaway: 220, C220	0–80	0.6–2.0	0.20–0.23	6.1–7.3

properties of soils—Continued

Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
Moderate	High	Moderate	0.32	3	6
High	High	Moderate	0.32		
Moderate	High	Moderate	0.32		
Moderate	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	Moderate	Moderate	0.37		
Low	Moderate	Moderate	0.37	3	6
Moderate	Moderate	Moderate	0.37		
Low	Moderate	Moderate	0.37		
Low	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Low	Moderate	Moderate	0.28		
Moderate	High	Moderate			6
High	High	Moderate			
Moderate	High	Moderate			
Low	High	Moderate			6
Low	High	Moderate			
High	High	Moderate			
High	High	Moderate			
Low	High	Moderate	0.37	3	6
High	High	Moderate	0.37		
Moderate	High	Moderate	0.37		
Low	High	High	0.43	3	6
High	High	High	0.43		
High	High	Moderate	0.43		
High	High	Moderate			7
High	High	Moderate			
Low	Low	Moderate	0.20	4	3
Low	Low	Moderate	0.20		
Low	Low	Moderate	0.15		
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

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/hr*	*In/in*	*pH*
Clarinda:				
222C, 222C2, 222D, 222D2	0–7	0.2–0.6	0.17–0.19	5.1–6.5
	7–33	<0.06	0.14–0.16	5.1–6.5
	33–65	<0.06	0.14–0.16	5.6–7.3
Wabash:				
248	0–17	0.06–0.2	0.21–0.24	5.6–7.3
	17–72	<0.06	0.08–0.12	5.6–7.8
Humeston:				
269	0–13	0.2–2.0	0.21–0.23	5.1–6.0
	13–26	0.2–2.0	0.20–0.22	4.5–6.0
	26–63	<0.06	0.13–0.15	4.5–6.5
Olmitz:				
273B	0–33	0.6–2.0	0.19–0.21	5.6–6.5
	33–63	0.6–2.0	0.15–0.17	5.1–6.5
Haig:				
362	0–7	0.6–2.0	0.22–0.24	5.6–6.5
	7–24	0.6–2.0	0.21–0.23	5.1–6.0
	24–44	<0.2	0.12–0.14	5.1–6.0
	44–65	0.2–0.6	0.18–0.20	6.1–7.3
Grundy:				
364B	0–11	0.6–2.0	0.22–0.24	5.6–7.3
	11–24	0.2–0.6	0.18–0.20	5.6–6.0
	24–37	0.06–0.2	0.11–0.13	5.1–6.5
	37–60	0.06–0.2	0.18–0.20	5.6–7.3
Macksburg:				
368, 368B	0–22	0.6–2.0	0.21–0.23	5.1–6.5
	22–43	0.2–0.6	0.18–0.20	5.1–6.0
	43–67	0.2–0.6	0.18–0.20	5.6–6.5
Winterset:				
369	0–18	0.2–0.6	0.21–0.23	5.6–7.3
	18–42	0.06–0.6	0.14–0.18	5.6–6.5
	42–75	0.2–0.6	0.18–0.20	6.1–7.3
Sharpsburg:				
370B, 370C, 370C2, 370D	0–13	0.6–2.0	0.21–0.23	5.1–6.5
	13–40	0.2–0.6	0.18–0.20	5.1–6.0
	40–62	0.2–0.6	0.18–0.20	6.1–6.5
Nira:				
[1] 371C:				
Nira part	0–13	0.6–2.0	0.21–0.23	5.6–6.5
	13–30	0.2–0.6	0.18–0.20	5.6–6.0
	30–60	0.6–2.0	0.18–0.20	5.6–6.5
Sharpsburg part	0–13	0.6–2.0	0.21–0.23	5.1–6.5
	13–40	0.2–0.6	0.18–0.20	5.1–6.0
	40–62	0.2–0.6	0.18–0.20	6.1–6.5
[1] 371C2:				
Nira part	0–13	0.6–2.0	0.21–0.23	5.6–6.5
	13–30	0.2–0.6	0.18–0.20	5.6–6.0
	30–60	0.6–2.0	0.18–0.20	5.6–6.5
Sharpsburg part	0–13	0.6–2.0	0.21–0.23	5.1–6.5
	13–40	0.2–0.6	0.18–0.20	5.1–6.0
	40–62	0.2–0.6	0.18–0.20	6.1–6.5
Keswick:				
425C	0–11	0.6–2.0	0.14–0.18	4.5–6.0
	11–35	0.06–2.0	0.11–0.15	4.5–6.0
	35–64	0.2–0.6	0.12–0.16	4.5–6.0

properties of soils—Continued

Shrink-swell potential	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete	Erosion factors: K	Erosion factors: T	Wind erodibility group
Moderate	High	Moderate	0.37	3	7
High	High	Moderate	0.37		
High	High	Moderate	0.37		
High	High	Moderate	----	----	4
Very high	High	Moderate	----		
Moderate	High	Moderate	0.32	4	7
Moderate	High	Moderate	0.32		
High	High	Moderate	0.32		
Moderate	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Moderate	High	Moderate	----	----	6
High	High	Moderate	----		
High	High	Moderate	----		
High	High	Low	----		
Moderate	High	Low	0.37	3	6
High	High	Low	0.37		
High	High	Moderate	0.37		
High	High	Low	0.37		
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		
Moderate	Moderate	Moderate	0.32	5	7
High	Moderate	Moderate	0.43		
Moderate	Moderate	Moderate	0.43		
Moderate	Moderate	Moderate	0.32	5	7
High	Moderate	Moderate	0.43		
Moderate	Moderate	Low	0.43		
Moderate	Moderate	Moderate	0.32	5	7
High	Moderate	Moderate	0.43		
Moderate	Moderate	Moderate	0.43		
Moderate	Moderate	Moderate	0.32	5	7
High	Moderate	Moderate	0.43		
Moderate	Moderate	Low	0.43		
Moderate	High	Moderate	0.37	3	6
High	High	Moderate	0.37		
Moderate	High	Moderate	0.37		

TABLE 11.—*Physical and chemical*

Soil name and map symbol	Depth	Permeability	Available water capacity	Soil reaction
	In	*In/in*	*In/in*	*pH*
Caleb:				
451C2, 451D2, 451E2	0–14	0.6–2.0	0.14–0.18	4.5–6.0
	14–32	0.2–0.6	0.14–0.18	4.5–6.0
	32–72	0.6–2.0	0.12–0.16	6.1–6.5
Lineville:				
452C	0–11	0.6–2.0	0.16–0.20	6.1–6.5
	11–23	0.2–0.6	0.17–0.21	5.1–6.0
	23–58	0.06–0.2	0.17–0.21	5.6–6.0
	58–72	<0.06	0.13–0.21	5.6–7.3
Mystic:				
592C2, 592D2	0–12	0.6–2.0	0.22–0.24	4.5–6.0
	12–54	0.06–0.2	0.15–0.19	4.5–6.5
	54–62	0.6–2.0	0.16–0.18	6.1–6.5
Armstrong:				
792C, 792C2, 792D2	0–10	0.6–2.0	0.20–0.22	5.6–6.5
	10–31	0.06–0.2	0.11–0.16	5.1–6.5
	31–60	0.2–0.6	0.14–0.16	5.1–6.5
Lamoni:				
822C, 822C2, 822D, 822D2	0–12	0.2–0.6	0.17–0.21	5.1–6.5
	12–31	<0.2	0.13–0.17	5.1–6.5
	31–71	0.06–0.2	0.14–0.18	6.1–6.5
Gara:				
[1] 993D2:				
Gara part	0–12	0.6–2.0	0.20–0.22	5.6–6.0
	12–40	0.2–0.6	0.16–0.18	5.1–6.5
	40–60	0.2–0.6	0.16–0.18	6.6–7.8
Armstrong part	0–10	0.6–2.0	0.20–0.22	5.6–6.5
	10–31	0.06–0.2	0.11–0.16	5.1–6.5
	31–60	0.2–0.6	0.14–0.16	5.1–6.5
[1] 993E2:				
Gara part	0–12	0.6–2.0	0.20–0.22	5.6–6.0
	12–40	0.2–0.6	0.16–0.18	5.1–6.5
	40–60	0.2–0.6	0.16–0.18	6.6–7.8
Armstrong part	0–10	0.6–2.0	0.20–0.22	5.6–6.5
	10–31	0.06–0.2	0.11–0.16	5.1–6.5
	31–60	0.2–0.6	0.14–0.16	5.1–6.5

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

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 hazard 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.

properties of soils—Continued

Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
	Uncoated steel	Concrete	K	T	
Low	Moderate	Moderate	0.28	5	6
Moderate	Moderate	Moderate	0.28		
Low	Moderate	Moderate	0.28		
Moderate	High	Moderate	0.37	3	6
Moderate	High	Moderate	0.37		
Moderate	High	Moderate	0.37		
High	High	Moderate	0.37		
Low	Moderate	Moderate	0.37	3	6
Moderate	Moderate	Moderate	0.37		
Low	Moderate	Moderate	0.37		
Moderate	High	Moderate	0.32	3	6
High	High	Moderate	0.32		
Moderate	High	Moderate	0.32		
Moderate	High	Moderate	0.32	3	7
High	High	Moderate	0.32		
High	High	Moderate	0.32		
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	0.28	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		

behavior of the whole mapping unit.

Depth to bedrock is shown for all soils that are underlain by bedrock at a depth of 5 to 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 the Soils

This part of the survey describes the factors that have affected the formation of the soils in Union

TABLE 12.—*Soil and*

[Absence of an entry indicates the feature is not a concern. See text for descriptions of

Soil name and map symbol	Hydro-logic groups	Flooding		
		Frequency	Duration	Months
Judson: 8B	B	None		
Colo: [1] 11B: Colo part	B/D	Common	Brief	Mar-Jun
Ely part	B	None		
Nodaway: [1] 13B: Nodaway part	B	Common	Brief	Feb-Nov
Vesser part	C	Common	Long	Feb-Nov
Arispe: 23C	C	None		
Shelby: 24C, 24C2, 24D, 24D2, 24D3, 24E, 24E2, 24F2	B	None		
Vesser: 51	C	Common	Long	Feb-Nov
Lindley: 65E, 65F	C	None		
Clearfield: 69C	C	None		
Ladoga: 76B, 76C, 76C2, 76D, T76B, T76C	B	None		
Adair: [1] 93D: Adair part	D	None		
Shelby part	B	None		
[1] 93D2: Adair part	D	None		
Shelby part	B	None		
[1] 93E2: Adair part	D	None		
Shelby part	B	None		
Mystic: [1] 94D2: Mystic part	D	None		
Caleb part	B	None		
Sperry: 122	C/D	Frequent	Very brief to long	Apr-Jul
Belinda: T130	D	None		
Pershing: 131C, 131C2, 131D, T131B, T131C	C	None		
Weller: 132C	C	None		
Colo: 133, 133B	B/D	Common	Brief	Mar-Jun

water features

symbols and such terms as "rare," "brief," and "perched." The symbol > means greater than]

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
>6.0			>60		High.
1.0–3.0	Apparent	Nov-May	>60		High.
3.0–5.0	Apparent	Nov-Apr	>60		High.
>6.0			>60		High.
1.0–3.0	Apparent	Nov-May	>60		High.
3.0–5.0	Perched	Apr-Jun	>60		High.
>6.0			>60		Moderate.
1.0–3.0	Apparent	Nov-May	>60		High.
>6.0			>60		Moderate.
1.0–3.0	Perched	Apr-Jul	>60		High.
>6.0			>60		High.
1.0–3.0	Perched	Nov-Mar	>60		High.
>6.0			>60		Moderate.
1.0–3.0	Perched	Nov-Mar	>60		High.
>6.0			>60		Moderate.
1.0–3.0	Perched	Nov-Mar	>60		High.
>6.0			>60		Moderate.
3.0–5.0	Perched	Nov-Mar	>60		High.
3.0–5.0	Perched	Nov-Mar	>60		Moderate.
0–3.0	Apparent	Nov-Jun	>60		High.
0–3.0	Perched	Apr-Jul	>60		Moderate.
2.0–4.0	Perched	Apr-Jul	>60		High.
2.0–4.0	Perched	Apr-Jul	>60		High.
1.0–3.0	Apparent	Nov-May	>60		High.

TABLE 12.—*Soil and*

Soil name and map symbol	Hydrologic groups	Flooding: Frequency	Flooding: Duration	Flooding: Months
Dickinson: 175D	B	None		
Gara: 179D, 179D2, 179E, 179E2, 179F	C	None		
Adair: 192C, 192C2, 192D2	D	None		
Kennebec: 212	B	Common	Brief	Feb-Nov
Nodaway: 220, C220	B	Common	Brief	Feb-Nov
Clarinda: 222C, 222C2, 222D, 222D2	D	None		
Wabash: 248	D	Common	Brief to long	Nov-May
Humeston: 269	C	Rare		
Olmitz: 273B	B	None to rare		
Haig: 362	C/D	None		
Grundy: 364B	C	None		
Macksburg: 368, 368B	B	None		
Winterset: 369	C	None		
Sharpsburg: 370B, 370C, 370C2, 370D	B	None		
Nira: [1] 371C:				
Nira part	B	None		
Sharpsburg part	B	None		
[1] 371C2:				
Nira part	B	None		
Sharpsburg part	B	None		
Keswick: 425C	D	None		
Caleb: 451C2, 451D2, 451E2	B	None		
Lineville: 452C	C	None		
Mystic: 592C2, 592D2	D	None		
Armstrong: 792C, 792C2, 792D2	D	None		

water features—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
>6.0			>60		Moderate.
>6.0			>60		Moderate.
1.0–3.0	Perched	Nov-Mar	>60		High.
2.0–5.0	Apparent	Nov-May	>60		High.
>6.0			>60		High.
1.0–3.0	Perched	Nov-May	>60		Moderate.
0–1.0	Perched	Nov-May	>60		Moderate.
1.0–3.0	Apparent	Nov-Apr	>60		High.
>6.0			>60		Moderate.
0–3.0	Perched	Apr-Jul	>60		High.
1.0–3.0	Perched	Mar-May	>60		Moderate.
2.0–4.0	Perched	Apr-Jul	>60		High.
0–3.0	Perched	Apr-Jul	>60		High.
>6.0			>60		High.
>6.0			>60		High.
>6.0			>60		High.
>6.0			>60		High.
>6.0			>60		High.
1.0–3.0	Perched	Nov-Mar	>60		High.
3.0–5.0	Perched	Nov-Mar	>60		Moderate.
1.0–3.0	Perched	Nov-Mar	>60		High.
3.0–5.0	Perched	Nov-Mar	>60		High.
1.0–3.0	Perched	Nov-Mar	>60		High.

TABLE 12.—*Soil and*

Soil name and map symbol	Hydrologic groups	Flooding		
		Frequency	Duration	Months
Lamoni:				
822C, 822C2, 822D, 822D2	D	None		
Gara:				
[1] 993D2:				
Gara part	C	None		
Armstrong part	D	None		
[1] 993E2:				
Gara part	C	None		
Armstrong part	D	None		

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

County. It also explains the system of soil classification. Detailed descriptions of profiles considered representative of the series are in the section "Descriptions of the Soils." This information is useful to scientists, teachers, students, and others interested in the formation and classification of soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes 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 development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Usually a long time is required for the development of distinct horizons.

The factors of soil genesis (*23*) are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The soils of Union County formed from three kinds of geologic materials (*26*). The deposits in the order of their influence on the soils of the county are loess, glacial till, and alluvium. The relationships of some of the major soils and their parent material are shown in figures 3, 4, and 5. The deposition of the various deposits in Union County and the subsequent geologic erosion have resulted in the formation of a landscape characterized by broad stable ridgetops occupied by soils that formed in glacial till and loess, and numerous large and small stream valleys where soils formed in alluvium. Union County has a similar landscape to that of Adair County, which adjoins the county on the north. In Adair County, a detailed study has been made of the landscape evolution and soil formation by R.V. Ruhe, R.B. Daniels, and J.G. Cady (*21*). This study will be referred to in several places on subsequent pages.

Loess.—Loess is a silty, wind-deposited material that consists largely of silt particles. It has smaller amounts of clay and sand. It is the most extensive parent material in Union County. Loess was deposited during the Wisconsin glacial period from about 24,500 to 14,000 years ago (*16, 21*). The loess is believed to have been blown mainly from the Missouri River flood plain along the western side of Iowa (*7*). The thickness of the loess and the differences between soils formed in loess are related to the distance from its source (*7*). The thickness of the loess in Union County is about 10 to 14 feet on the nearly level, stable divides. It is thinner on the side slopes. On most side slopes on the higher uplands, all the loess has been removed by erosion, and glacial till is exposed on the surface.

The loess of southwest and southern Iowa gradually thins and becomes finer textured from west to east (*7*). The variation is not great in Union County.

Winterset, Macksburg, Sharpsburg, Nira, and Grundy are the most extensive soils in Union County that formed in loess. Clearfield, Sperry, and Ladoga soils are less extensive.

The loess and soils formed in loess in western and southwestern Iowa have been the subject of much study and investigation. Ruhe and others (*5, 15, 20, 21*) have studied the relationship of the loess to the topography in western Iowa. Davidson and associates (*3*) studied the physical and engineering properties of loess in western Iowa and elsewhere. Ullrich (*27, 28*) *water features*—Continued

High water table			Bedrock		Potential frost action
Depth	Kind	Months	Depth	Hardness	
Ft			*In*		
1.0–3.0	Perched	Nov-May	>60		Moderate.
>6.0			>60		Moderate.
1.0–3.0	Perched	Nov-Mar	>60		High.
>6.0			>60		Moderate.
1.0–3.0	Perched	Nov-Mar	>60		High.

behavior of the whole mapping unit.

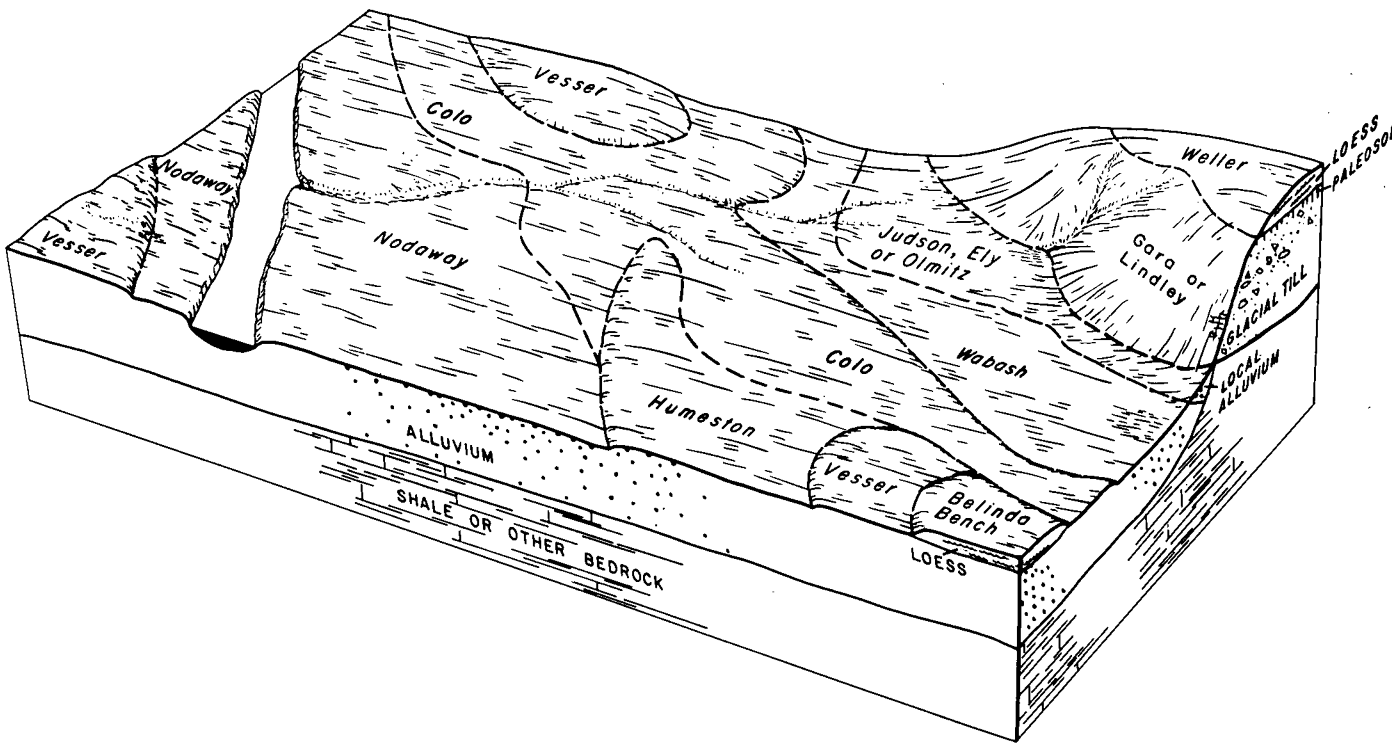

***Figure 3.*—Typical pattern of soil and parent material in Nodaway-Colo-Wabash soil association.**

studied physical and chemical changes accompanying soil profile formation in soils formed in loess in southwest Iowa. Among the soils he studied was Winterset. Other chemical and physical data on Winterset, Macksburg, and Sharpsburg soils have been reported (*22, 30*).

Glacial till.—Two glaciers deposited material in Union County, the Nebraskan, and later the Kansan. The Nebraskan till can be identified on the landscape. It occurs in a few places in the eastern part. The Kansan till is exposed in all parts of the county and, on steep slopes, forms an extensive part of the landscape. The unweathered till is a firm calcareous clay loam. It contains pebbles, boulders, and sand, as well as silt and clay. The till is a heterogeneous mixture and shows little evidence of sorting or stratification. The mineral composition of its components is also heterogeneous (*11*) and is similar to that of particles in unweathered loess.

Observations made during the survey show that the glacial deposits in Union County range to a depth of 100 feet or more. The thickness, hardness, or absence of the underlying sediments or rock has apparently had a direct effect on the thickness of the glacial till.

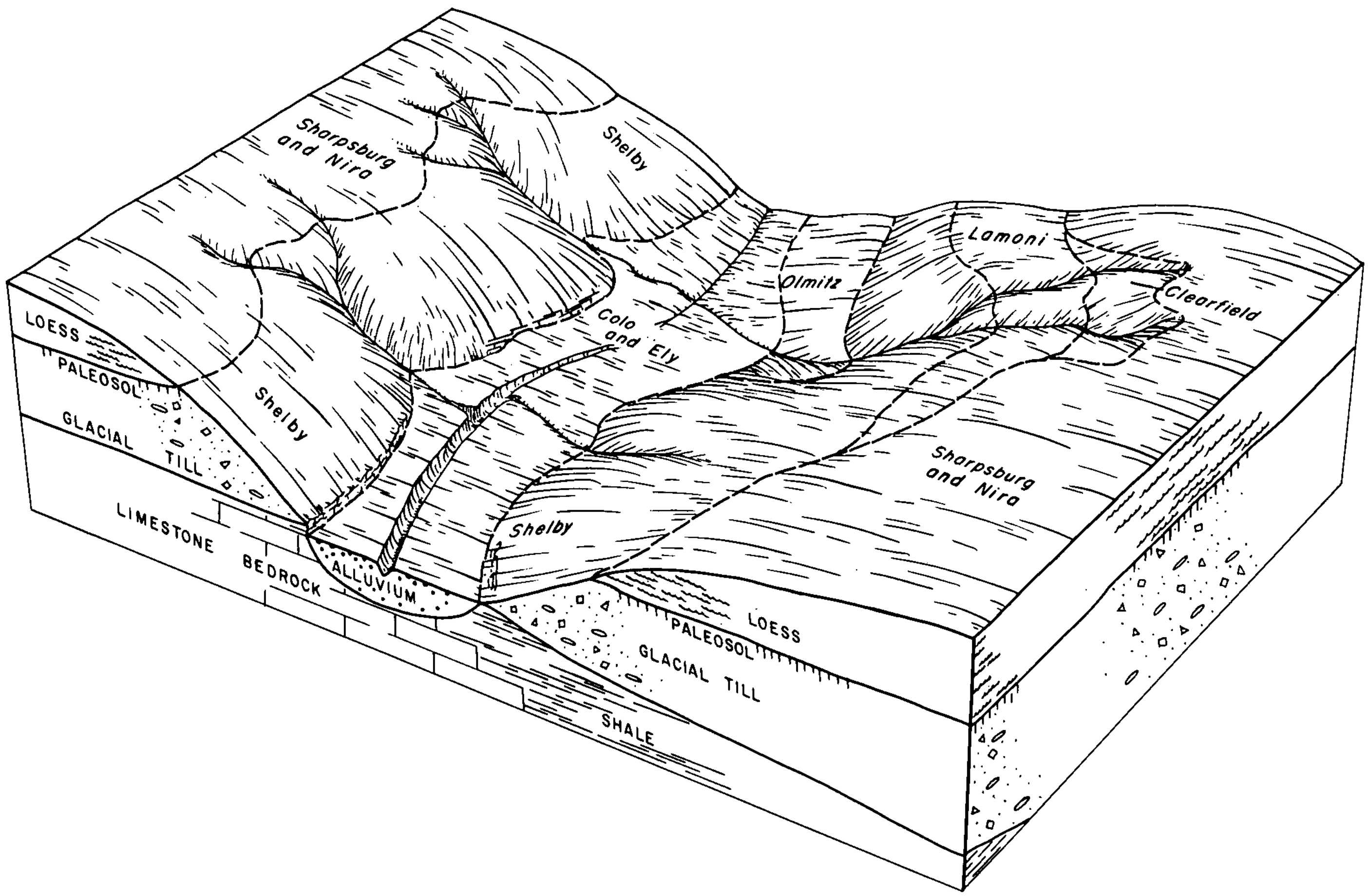

***Figure 4.*—Typical pattern of soil and parent material in Sharpsburg-Shelby-Nira soil association.**

Soils developed on the Kansan till plain during the Yarmouth and Sangamon interglacial periods before the loess was deposited (*20*). In nearly level areas, the soils were strongly weathered and had a gray plastic subsoil called "gumbotil" (*9, 10, 17, 20*). This gumbotil is several feet thick and very slowly permeable. A widespread erosion surface has cut below the Yarmouth-Sangamon paleosol into Kansan till and older deposits. The surface is characterized generally by a stone line or subadjacent sediment and is surmounted by pedisediment (*17, 18, 19*). Paleosols formed in the pedisediment stone line and the subadjacent till (fig. 6). This surface is of Late Sangamon age. The paleosols were more reddish and were not so strongly weathered and not so thick as those on the nearly level areas.

The soils that formed on the Kansan till during Yarmouth and Sangamon time were covered by loess. Geologic erosion has removed the loess from many slopes and has exposed these paleosols. In some places the paleosols have been beveled or truncated so that only the lower part of the strongly weathered paleosol remains. This erosion took place before the loess deposition, or more than 25,000 years ago (*20*). In other places, erosion has removed all of the paleosol and has exposed till that is only slightly weathered at the surface. This erosion mostly took place in post-glacial times (*20*).

The Clarinda soils formed in the strongly weathered, Yarmouth-Sangamon gray clay paleosol. Lamoni soils formed in the truncated Yarmouth-Sangamon paleosol. Their clay layer is not so thick as Clarinda soils. The Adair and Keswick soils formed where the less strongly weathered, reddish paleosol crops out. The Shelby, Gara and Lindley soils formed in slightly weathered glacial till.

The Caleb and Mystic soils formed in pre-Sangamon erosional sediment of varied texture and glacial origin. This material appears to have been angularly truncated in many places. In many places it occurs as an irregular mixture of material of contrasting textures. Caleb and Mystic soils are on extended, stepped interfluves above the present drainage system. They owe their landscape configuration partly to valley fill, but their surfaces blend with the present erosional uplands. These areas are distinctly higher in elevation than the northern flood plain, but they are lower than the late Wisconsin, recent dissection slopes on which the Gara, Shelby, and Lindley soils formed. The Mystic soils are on the most stable parts of interfluves and have inherited many of their characteristics from the Late-Sangamon paleosol. Caleb soils are downslope on

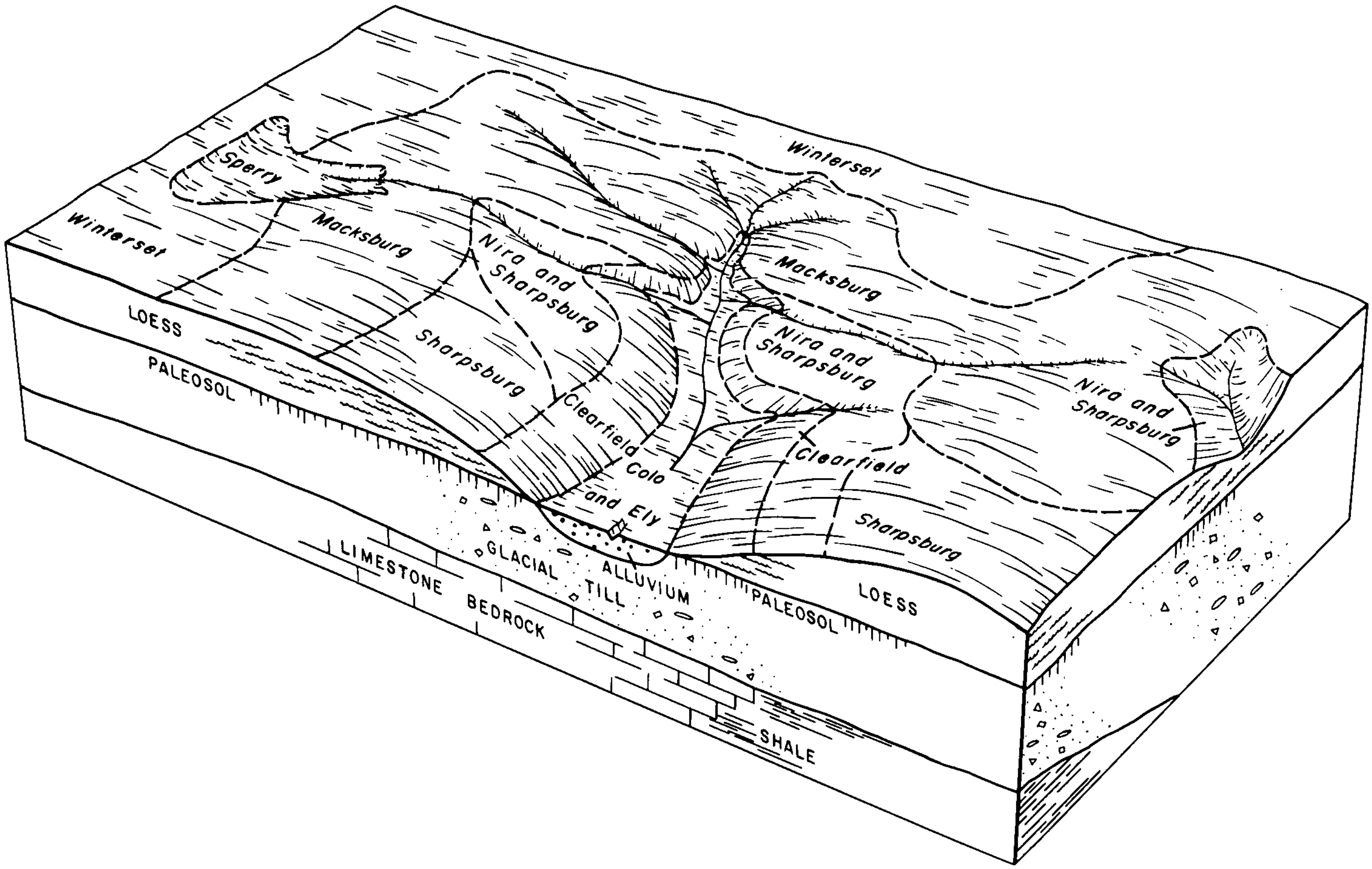

Figure 5.—**Typical pattern of soil and parent material in Macksburg-Winterset soil association.**

the parts of the interfluves that were truncated in recent (Wisconsin) time.

Alluvium.—Alluvium consists of sediments deposited along major and minor streams and drainageways. It is also on benches. It varies widely because of differences in materials from which it was derived and the manner in which it was deposited. Loess and glacial till have been the main sources of alluvium in Union County.

The alluvial material that has been transported only short distances is called local alluvium. It retains many characteristics of the soils from which it has been washed. Judson soils, for example, generally are at the base of slopes below soils that formed in loess. They are silty and have textures similar to those of the soils upslope. Olmitz soils also formed in local alluvium but are downslope from till-derived soils. They contain more sand than Judson soils because the alluvium in which they formed came from sandier soils. Colo and Ely soils also formed in local alluvium.

As the rivers and streams overflow their channels, the coarse textured sandy material is deposited first, adjacent to the stream. As the water spreads outward toward the uplands, it moves more slowly and deposits the silt and very fine sand. In high floods, the water spreads slowly toward the outer border of the flood plain carrying very fine silt and clay particles. As the floods recede, these particles settle and are mixed with the fine particles washed down by local alluvium.

This pattern is demonstrated many times on the wider stream bottoms of the Grand River. Away from the areas of alluvial land nearest the streams are Nodaway soils and then Kennebec soils. The Nodaway soil is coarse silt with some fine sand and clay. The Kennebec soil is siltier with less sand and more clay. Colo and Wabash soils, which are farther away from the main channel, are the finest textured and most poorly drained soils. They are somewhat lower in elevation than the other soils.

Main stream benches or second bottoms have formed in the eastern part of the county. On these are the alluvial soils that range widely in texture, are much less subject to overflow, and have more profile development. These soils are the somewhat poorly drained to poorly drained Vesser silt loams.

Eolian (*windblown*) *sand.*—This material is largely fine quartz sand, which, in Union County, is mixed with some silt. It has blown up from nearby stream bottoms and has been deposited on nearby ridgetops and side slopes. It occurs as small areas, some of which are large enough to be mapped. Others are identified by spot symbols on the soil map.

Figure 6.—Stone line in reddish paleosol buried under about 8 feet of light-colored loess.

Climate

Union County soils, according to recent evidence, have been developing under variable climatic conditions. Walker (*31*) in his recent studies concluded that in the Post Cary glaciation period, about 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominated by conifers. Between 10,500 to 8,000 years ago, there was a warming trend and the vegetation changed from conifers to mixed forest. Hardwoods were prominent (*4*). Beginning about 8,000 years ago, the climate became warmer and drier. Herbaceous prairie fauna became dominant and are still dominant. McComb and Loomis (*12*) concluded, from studies of the forest-prairie transition of central Iowa, that a late change in post glacial climate from relatively dry prairie to more mesic conditions had taken place. Walker's evidence indicates that this change may have begun about 3,000 years ago. The present climate in Union County is midcontinental subhumid.

Nearly uniform climate prevails throughout the county. The influence of the general climate, however, is modified by local conditions in or near the developing soil. For example, south-facing slopes have a micro-climate that is warmer and less humid than the average climate of nearby areas. Low-lying, poorly drained bottoms are wetter and colder than most areas around them.

The general climate has had an important overall influence on the characteristics of the soils but has not caused major differences among them. The local differences in climate do account for some differences.

Weathering of the parent material by water and air is activated by changes in temperature. As a result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its effect on the amount of leaching in soil and on the kinds of plants that grow.

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 changes in soils that are brought about by differences in plant and animal populations.

Plant and animal life

Several kinds of living organisms are important in soil development. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. Differences in the kind of vegetation commonly cause the most marked differences among soils (*13*).

The soils of Union County appear to have been influenced in recent times by two main types of vegetation: prairie grasses and trees. The main prairie grasses were big and little bluestem. The trees were mainly oak, hickory, ash, elm, and other deciduous trees.

Studies of the effects of vegetation on soils similar to those in Union County have been made by Cardoso,[2] McCracken,[3] White and Reicken (*32*).

Tall prairie grasses was the dominant vegetation in Union County when the broad, nearly level to gently rolling uplands were settled. Trees, near most major streams and their major tributaries, occupied about 30,000 acres at the time of settlement.

Because grasses have many roots and tops that have decayed on or in the soil, soils formed under prairie vegetation typically have thicker, darker colored surface layers than soils that formed under trees. Under trees, the organic matter, derived principally from leaves, was deposited mainly on the surface layer of the soil, and soils that formed under trees generally are more acid and have had more downward movement of bases and clay minerals in their profiles.

The Sharpsburg and Macksburg are typical soils that developed in loess under prairie vegetation. Shelby soils developed in glacial till.

The Weller and Lindley soils developed under forest vegetation. Weller soils developed in loess and Lindley soils in glacial till. These soils have a thin, light colored A1 horizon, a prominent gray A2 horizon that is very distinct when dry, and a B horizon that has stronger structure and more evidence of the accumulation of silicate clay than that in prairie soils.

Ladoga and Gara soils have properties intermediate between those formed entirely under trees and those formed under grass. It is believed that these soils developed under prairie and that trees later encroached on the areas because soil morphology reflects the influence of both trees and grass.

Relief

Relief, or lay of the land, ranges from nearly level to very steep in Union County. It is an important factor in soil formation because of its effect on drainage, runoff, the height of the water table, and erosion. Difference in relief is the main reason for the differing soil properties of some soils in the county.

Even though soils form in the same parent material, the influence of relief is evident in the color, the thickness of the solum, and the development of horizons. The Sharpsburg, Sperry, Winterset, and Macksburg soils, for example, all formed in loess under similar vegetation, but at different topographic positions. Sperry soils, which are very poorly drained, occur in low places where water accumulates. Sharpsburg soils, which are well drained to moderately well drained, occur on slopes where some of the water runs off.

Water on soils either percolates downward or evaporates. The water that percolates through soils removes clay from the A horizon, and much of this clay accumulates in the B horizon. The Sperry soils in depressions have accumulated more clay in the B horizon than the sloping Sharpsburg soils, because more water percolates through the profile. The content of clay in the B horizon is generally greater in gently sloping or level soils than in steep soils. This clay content is progressively greater from Sharpsburg soils to Macksburg to Winterset to Sperry soils. The clay content in Winterset and Sharpsburg soils has been reported in detail by Ulrich (*27*, *28*) and Hutton (*7*, *8*) respectively.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown, because oxidized iron compounds are well distributed throughout the horizon. The subsoil of soils that have restricted drainage is generally grayish in color and is mottled. Sperry soils, which are in depressions, have a grayish B horizon. The sloping Sharpsburg soils have a brownish B horizon.

In soils like Shelby, which occur on a wide range of slopes and landscapes, the depth to carbonates is systematically less as the percent of slope increases, and the slopes are more convex.

Slope affects runoff, which in turn affects the amount of moisture available to plants. The lack of moisture may have restricted the growth of plants on some of the steeper Shelby and Sharpsburg soils. This fact could account for differences in the thickness and organic-matter content of the surface layer of these soils.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in the parent material. Similar kinds of soil form in widely differing kinds of parent material if other factors continue to operate over long periods of time. Soil formation, however, generally is interrupted by geologic events that expose new parent material. In Union County new parent material has been added to the upland at least three times.

The bedrock in Union County has been covered by glacial drift from two different glaciers. Then, the present surface material, the loess, was deposited. As a result the soils have been buried, and further development of those soils has stopped.

According to studies by R. V. Ruhe and others (*20*), the Clarinda, Lamoni, Adair, and Keswick soils have subsoil horizons that are the most weathered in the county. These soils formed in Kansan till which began to weather in Yarmouth and Sangamon times. Then they were covered by loess. More recently the upper part of this ancient subsoil was exposed to weathering again when the loess was removed by erosion. Such soils as Clarinda, Lamoni, Keswick, Adair, and Mystic are referred to as paleosols. Even older are the beds of limestone shale and sandstone, which lie below the glacial till.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating soils formed partly in Wisconsin

[2] CARDOSO, J. 1957. SEQUENCE RELATIONSHIPS OF CLARION, LESTER, AND HAYDEN SOIL CATENAS. (Unpublished PhD thesis. Iowa State University Library, Ames, Iowa)

[3] MCCRACKEN, R. 1956. SOIL CLASSIFICATION IN POLK COUNTY, IOWA. (Unpublished PhD thesis. Iowa State University Library, Ames, Iowa)

age (*14, 15, 21*). Loess deposition began about 25,000 years ago and continued to about 14,000 years ago (*6*). Based on these dates, soil material in the surface of nearly level loess mantled divides in Iowa is about 14,000 years old. Among the stable areas in Union County are the nearly level and most of the gently sloping divides occupied mainly by Winterset, Macksburg, and Sharpsburg soils. In much of Iowa, including Union County, geologic erosion has beveled and, in places, removed material on side slopes and deposited new sediments downslope (*21*). The soil material on the surfaces of nearly level upland divides is older than that on the slopes that have been beveled and that ascend to the divides. Thus, the side slopes are less than 14,000 years old. The Shelby, Gara, and Lindley soils in Union County are on side slopes.

The sediment stripped from side slopes accumulated to form local alluvium. The age of soil materials on side slopes is determined by the alluvial fill at the base of slopes. Studies by Ruhe, Daniels, and Cady (*21*) in neighboring Adair County indicate that the base of the alluvial fill is about 6,800 years old. Daniels and Jordan (*5*) found the alluvium in some stream valleys in western Iowa to be less than 1,800 years old. Because the sediments from the side slopes accumulated to form the alluvium, the soil material on the surface of the side slopes in these areas is as young or younger than those dates. Among the soils formed in similar alluvium in Union County are Ely, Kennebec, Olmitz, Judson, and Wabash soils. Nodaway soils also formed in alluvium, some of which was deposited since settlement by man.

Man's Influence on the Soil

Important changes have taken place in the soils since Union County was settled. Breaking the prairie sod and clearing the timber removed and changed the protective soil cover.

The most apparent changes are those caused by water erosion. As the land was cultivated, the rate at which water moved into the soil decreased and surface runoff increased. This increased runoff resulted in accelerated erosion, which has removed part or all of the original surface layer from much of the cultivated sloping land. In some places, shallow to deep gullies have formed.

Erosion has changed not only the thickness of the surface layer, but also the structure and consistence. In most severely eroded areas, the plow layer is a mixture of the original surface layer and material from the upper part of the subsoil, which is less friable and finer textured than the surface layer.

Erosion and cultivation also affect the soil by reducing the organic-matter content and lowering the fertility. Even in areas that are not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and changes its structure. The granular structure that is so apparent in virgin grassland breaks down under intensive cropping.

Man, however, can and has done much to increase soil productivity, decrease soil loss, and reclaim areas not suited to crops or pasture. Terraces, erosion control structures, and other erosion control practices have reduced and in some places controlled runoff and erosion. Diversions at the base of slopes and drainage ditches have helped prevent flooding and deposition and made large areas of bottom land suitable for cultivation. Deficiencies in plant nutrients have been corrected through the use of commercial fertilizers and lime, so that many soils are now more productive than they were in the virgin state.

Erosion is one of the main causes of the reduction of organic matter in soils. Figures indicate (*25*), however, that as much as one-third of the organic matter can be lost through causes other than erosion. Management practices have shown that it is not economically feasible to maintain so high a reserve of organic matter as was originally present under native grasses. It is necessary, however, to maintain a safe and economical level for crop production. On the soils lowest in organic matter, maintaining this level is best done by controlling the major cause of loss—erosion by water.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation. First through classification and then through use of soil maps we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study. Therefore, readers interested in development of the current system should search the latest literature available (*24, 29*). In table 13, the soil series of Union County are placed in some categories of the current system.

The current system of classification has six categories. Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measureable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped together. Most of the classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates. Table 13 shows that the three soil orders in Union County are Entisols, Mollisols, and Alfisols.

Entisols are light colored soils that do not have natural genetic horizons or that have only weakly

TABLE 13.—*Classification of the soils*

Soil name	Family or higher taxonomic class
Adair	Fine, montmorillonitic, mesic Aquic Argiudolls
Arispe	Fine, montmorillonitic, mesic Aquic Argiudolls
Armstrong	Fine, montmorillonitic, mesic Aquollic Hapludalfs
Belinda	Fine, montmorillonitic, mesic Mollic Albaqualfs
Caleb	Fine-loamy, mixed, mesic Mollic Hapludalfs
Clarinda	Fine, montmorillonitic, mesic, sloping Typic Argiaquolls
Clearfield	Fine, montmorillonitic, mesic, sloping Typic Haplaquolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Dickinson	Coarse-loamy, mixed, mesic Typic Hapludolls
Ely	Fine-silty, mixed, mesic Cumulic Hapludolls
Gara	Fine-loamy, mixed, mesic Mollic Hapludalfs
Grundy	Fine, montmorillonitic, mesic Aquic Argiudolls
Haig	Fine, montmorillonitic, mesic Typic Argiaquolls
Humeston	Fine, montmorillonitic, mesic Argiaquic Argialbolls
Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
Kennebec	Fine-silty. mixed, mesic Cumulic Hapludolls
Keswick	Fine, montmorillonitic, mesic Aquic Hapludalfs
Ladoga	Fine, montmorillonitic, mesic Mollic Hapludalfs
Lamoni	Fine, montmorillonitic, mesic Aquic Argiudolls
Lindley	Fine-loamy, mixed, mesic Typic Hapludalfs
Lineville	Fine-loamy, mixed, mesic Aquollic Hapludalfs
Macksburg	Fine, montmorillonitic, mesic Aquic Argiudolls
Mystic	Fine, montmorillonitic, mesic Aquollic Hapludalfs
Nira	Fine-silty, mixed, mesic Typic Hapludolls
Nodaway	Fine-silty, mixed, nonacid, mesic Mollic Udifluvents
Olmitz	Fine-loamy, mixed, mesic Cumulic Hapludolls
Pershing	Fine, montmorillonitic, mesic Udollic Ochraqualfs
Sharpsburg	Fine, montmorillonitic, mesic Typic Argiudolls
Shelby	Fine-loamy, mixed, mesic Typic Argiudolls
Sperry	Fine, montmorillonitic, mesic Typic Argialbolls
Vesser	Fine-silty, mixed, mesic Argiaquic Argialbolls
Wabash	Fine, montmorillonitic, mesic Vertic Haplaquolls
Weller [1]	Fine, montmorillonitic, mesic Aquic Hapludalfs
Winterset	Fine, montmorillonitic, mesic Typic Argiaquolls

[1] These soils are taxadjunct to the Weller series.

expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling.

Mollisols formed under grass. They have a thick, dark colored surface horizon containing colloids dominated by divalent cations. The soil material has not been mixed by shrinking and swelling.

Alfisols are mineral soils that contain horizons of clay accumulation. Unlike Mollisols, they lack a thick, dark colored surface layer that contains colloids dominated by divalent cations, but the base status of the lower horizons is not extremely low.

SUBORDER. Each order is divided into suborders, primarily on the basis of the characteristics that seemed to produce classes that have the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP. Each suborder is divided into great groups on basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that contain a pan that interferes with the growth of roots or movement of water. The features used are the self-mulching properties of clay, the temperature, the major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium) and the like. The great group is not shown separately in table 13 because it is the last word in the name of the subgroup.

SUBGROUP. Each great group is divided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. Each subgroup is identified by the name of the great group preceded by one or more adjectives.

FAMILY. Soil families are established 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.

General Nature of the County

Union County was established in 1853. Creston is the county seat. The first settlers, in 1846, were the Mormons at Mt. Pisgah, just east of the Grand River. Many people going west followed the trail established by the Mormons on their way west to Salt Lake City.

Union County, in the bluegrass area of Iowa, was celebrated as the bluegrass capital of the world. The first Bluegrass Palace was constructed in 1889 and the last in 1892.

Union County is in the south central part of Iowa. It has an area of 272,000 acres. It is the fourth county east of the Missouri River and the second county north of the Missouri State line.

Creston, in the west central part of the county, is about the highest elevation in the county. The population in 1970 was 8,234. The population of Union County in 1970 was 13,557. The rural population and the population of the smaller towns are slowly decreasing. The population of Creston is increasing.

The county is primarily agricultural. Cattle, hogs, and sheep are raised on many farms. Corn is the principal grain crop. Soybeans, oats, hay, and pasture are the other crops. Except for soybeans, they are usually fed to livestock.

Topography

The original topography of the county, that of an upland plain, has been greatly modified by natural erosion and the trenching of streams. The trenching and landscape-shaping action of the larger streams and tributaries were greatly influenced by the geologic materials exposed below the original loess-mantled plain. The remnants of this plain now occupy a series of stable, loess-mantled divides throughout the county. These divides are less stable and more narrow in the eastern part of the county.

The highest elevation in the county is on the county line in the northwestern part of the county. The lowest is near the stream channel of the Grand River at the southeast corner.

The larger streams have formed valleys 100 to 250 feet below the upland plain. In many places, the south and west slopes are typically abrupt and steep. The valley north- and east-facing slopes are longer and less steep.

In the eastern part of the county, the topography is characterized by narrow, unstable divides, steep valley slopes, and nearly level bottom land and benches.

Most of the county, except along major streams, has topography typical of southern Iowa. The side slopes are rounded and uniform but range from gently sloping to steep. The long tributary streams that cut into thick deposits of glacial till extend far into the uplands.

Drainage

Two major streams and their tributaries provide the natural drainage of Union County. They are the Platte River in the west and the Grand River in the east. Runoff in the extreme northeast corner of the county flows into the South River, then into the Des Moines River, and eventually into the Mississippi. The northwestern part of the county is drained by tributaries of the Nodaway River.

Most of the natural drainage in the county flows into the Missouri River through the Grand and Platte River systems.

The main streams and the intermittent drainageways adequately drain most of the county. On some of the more level interstream upland areas supplemental drainage is needed. Some of the wetter bottom lands also require added drainage.

Farming

The following paragraphs explain the general nature of farming in Union County. Unless otherwise stated, information is from the 1971 edition of the Iowa Annual Farm Census.

Farm and farm tenure.—There were 865 farms in Union County in 1971, a total of 262,137 acres. The average farm was 303 acres. About 60 percent of the farms were owner operated. The trend is toward larger farms and fewer operators.

Crops and pastures.—In 1971, about 110,269 acres was cropland. Of this, 49,206 acres was in corn, 20,586 acres in soybeans, 27,478 acres in hay, and about 13,000 acres in small grain.

Row crops are usually grown in rotation with hay and pasture, but on the more level land, row crops are grown nearly every year.

In 1971, approximately 115,000 acres was pasture. Much of this acreage is improved pasture that is seeded to mixtures of grasses and legumes. Some pastures are in bluegrass. Most of the woodland is also grazed.

Livestock.—Raising and feeding beef cattle and hogs is the major enterprise in Union County. Approximately 8,331 grain-fed cattle and 80,553 hogs were marketed in 1971. There were 21,477 beef cattle, 731 dairy cows, and 12,447 sows farrowed. There were 2,465 lambs born and 1,814 grain-fed sheep and lambs marketed. Laying hens numbered 13,545.

The number of beef cattle has increased since 1961. The number of grain-fed cattle has decreased slightly along with the number of sows farrowed. The number of laying hens has decreased from 77,034 in 1961 to 13,545 in 1971. Dairy cows have also decreased from 3,612 to 731 during the same period.

Climate[4]

Union County is in the western part of south central Iowa. The records at Creston are representative of the rest of the county. Data on temperature and precipitation are listed in tables 14 and 15.

Annual precipitation ranges from about 30.4 inches in the west to 31.5 inches in the east. The greatest part of this difference occurs during the warm season. Average monthly values and the extreme values to be expected for a month, 1 year in 10, are given in table 14. June is the wettest month, and August is the second wettest. From 1951 to 1960, Creston averaged 20 days per year with half an inch or more of rainfall and 55 days with 0.10 or more.

About 75 percent of the warm-season rainfall occurs as showers that vary widely across the county and are sometimes heavy enough to cause erosion problems. Cool-season precipitation seldom falls as showers. The probability of receiving an inch or more of rainfall in a 1-week period is about 4 years out of 10 in June, and decreases to between 2 and 3 years out of 10 in July and August. Well developed crops use over an inch of water per week.

On an average of 33 days per year in Union County, the maximum temperature is equal to or greater than 90° F. Such temperatures are too high for optimum crop production. Minimum temperatures vary. Low areas have minimum temperatures lower than urban or upland areas on clear, calm nights.

The monthly temperature is listed in table 14. Probabilities of freezing temperatures in the spring and fall are listed in table 15. The average date of the last 32° in spring is April 30. The first in fall is October 12. The average growing season is 165 days.

For good crop production, warm-season rainfall and a moisture reserve in the subsoil in spring are needed. On April 15, the average moisture reserve in this area is about 7 inches. The chance of having less than 5 inches is about 30 percent. A reserve of 7 to 8 inches in spring is considered adequate. A level of 5 inches is considered critically low. In years when the reserve is 5 inches or less, better than normal warm-season rainfall is needed if average crop yields are to be obtained.

[4] Prepared by ROBERT H. SHAW, climatologist, Iowa State University.

TABLE 14.—*Temperature and precipitation*

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly highest maximum	Average monthly lowest minimum	Average monthly total	1 year in 10 will have— Less than—	1 year in 10 will have— More than—	Number days with snow over 1.0 in. or more	Average depth of snow on days with snow cover
	°F	°F	°F	°F	In	In	In		In
January	32	13	52	−14	1.0	0.3	1.7	18	4
February	36	16	56	−6	0.8	0.1	2.0	13	4
March	46	26	71	4	1.9	0.6	4.5	6	6
April	62	38	83	22	2.7	1.2	5.4	1	2
May	73	50	87	33	3.9	2.2	6.4		
June	82	60	93	45	4.8	2.5	8.6		
July	88	64	96	52	2.6	1.0	6.8		
August	85	62	95	48	4.5	1.2	8.5		
September	78	53	90	35	3.4	1.0	7.9		
October	66	42	83	23	2.0	0.1	4.1		
November	49	28	69	8	1.8	0.2	2.9	3	3
December	37	19	58	−5	1.0	0.2	2.3	9	3
Year	61	39	97	−16	30.4	24.6	40.0	50	4

TABLE 15.—*Probabilities of last freezing temperatures in spring and first in fall*

[Creston, Union County]

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. 7	Apr. 17	Apr. 25	May 1	May 15
2 years in 10 later than	Apr. 1	Apr. 11	Apr. 20	Apr. 26	May 10
5 years in 10 later than	Mar. 22	Mar. 31	Apr. 9	Apr. 16	Apr. 30
Fall:					
1 year in 10 earlier than	Oct. 28	Oct. 19	Oct. 11	Oct. 4	Sept. 27
2 years in 10 earlier than	Nov. 2	Oct. 24	Oct. 17	Oct. 9	Oct. 2
5 years in 10 earlier than	Nov. 13	Nov. 4	Oct. 28	Oct. 20	Oct. 12

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Alluvium, local. Soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Area reclaim. An area difficult to reclaim after the removal of soil or construction and other uses. Revegetation and erosion control are extremely difficult.

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 terrace. A raised, level or nearly level strip of earth constructed on or nearly on a contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Bottoms, first. The normal flood plain of a stream; land along the stream subject to overflow.

Bottoms, 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 magnesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures is difficult.

Compressible. Excessive decrease in volume of soft soil under load.

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.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Erosion. The wearing away of the land surface by running water, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Excess fines. Excess silt and clay. The soil does not provide a source of gravel or sand for construction purposes.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Frost action. Freezing and thawing of soil moisture. Frost action can damage structures and plant roots.

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 outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by melt water as it flows from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil having one or more neutral gray horizons as a result of waterlogging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent waterlogging.

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, alumnium, 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 block 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.

Interfluve. The land between two adjacent streams flowing in the same general direction.

Leaching. The removal of soluble material from soil or other material by percolating water.

Loess. Fine granulated material, dominantly of silt-sized particles, deposited by wind.

Low strength. Inadequate strength for supporting loads.

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 often 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.

Percolation. The downward movement of water through the soil.

Percs slowly. The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

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

Relief. The elevations or inequalities of a land surface, considered collectively.

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.

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.

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.

Substratum. The part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

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.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt, 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."

Thin layer. Otherwise suitable soil material too thin for the specified use.

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

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 level 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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