SOIL SURVEY

Cass County Iowa

OUR SOIL ★ OUR STRENGTH

Issued April 1969

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
Iowa Agricultural Experiment Station

Major fieldwork for this soil survey was done in the period 1958–1962. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1966. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agricultural Experiment Station; it is part of the technical assistance furnished by the Soil Conservation Service to the Cass County Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Cass County 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 of the soils of Cass 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 "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit, or for any other group in which the soil has been placed.

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. 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 section that describes the soils and in the section that discusses management of the soils for cultivated crops and pasture. Then they can refer to the section "Woodland" for a brief discussion of the extent and types of woodland in the county, and the kinds of trees suitable for planting.

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

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

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

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

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SOIL SURVEY OF CASS COUNTY, IOWA

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

Cass County is in the southwestern part of Iowa (fig. 1). It has a total land area of 559 square miles, or 357,760 acres. Atlantic, the county seat, is 75 miles west of Des Moines, the State capital, and 45 miles northeast of Council Bluffs.

Most of the acreage in the county is in farms. Corn, soybeans, oats, hay, and pasture are the main crops, and corn is the principal grain crop. Most of the grain and forage that is grown on the farms is fed to the hogs and beef cattle that are raised in the county.

Most of the soils in Cass County formed under prairie and are dark colored and fertile. The climate is subhumid and continental. Winters are cold, summers are warm, and the growing season is long enough for the crops grown in the county to mature.

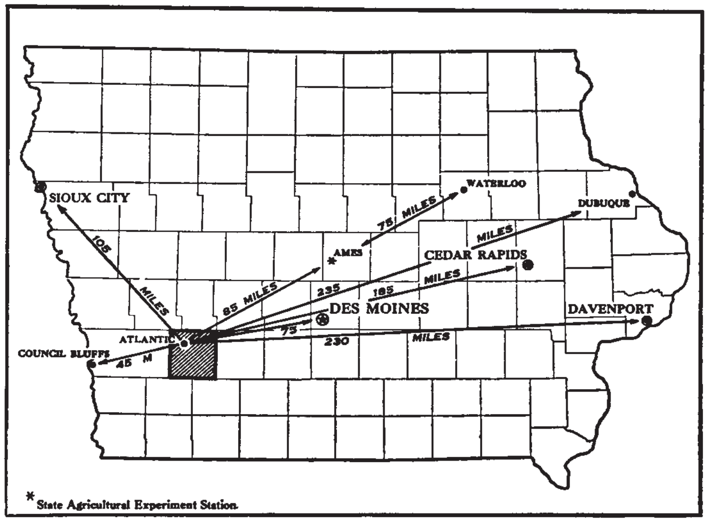

Figure 1.—**Location of Cass County in Iowa.**

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Cass 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; 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 nationwide 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. Marshall and Shelby, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in 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 of 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 layer is apparent from their names.

Some soil types vary so much in 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 soil 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, Marshall silty clay loam,

[1] Survey prepared under the general direction of W. J. B. Boatman, now deceased, and Lacy Harmon, State soil scientists, Soil Conservation Service, and F. F. Riecken, professor of soils, Iowa Agricultural Experimental Station.

0 to 2 percent slopes, is one of several phases of Marshall silty clay loam, a soil type that ranges from nearly level to moderately steep.

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

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning 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 mixed, 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, Judson-Colo complex, 2 to 5 percent slopes. The soil scientist may also show as one mapping unit two or more soils that have differences not significant enough to make it practical to show them separately on the map. Such a mapping unit is called an undifferentiated soil group. An example is Adair and Shelby soils, 9 to 14 percent slopes, severely eroded.

Most surveys also include areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. These areas are shown on the map like other mapping units, but they are given descriptive names, such as Alluvial land or Marsh, and are called land types.

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 soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. 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 a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil surveys. On the basis of yield and practice tables and other data, the soil scientists set up trial groups, and then test them by further study and by consultation with farmers, agronomists, engineers, and others. Then the scientists adjust the groups according to the results of their studies and consultation. Thus the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

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

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management.

The soil associations in Cass County are described in the pages that follow. Associations 1 through 5 are in the uplands, and associations 6 and 7 are along the rivers and smaller streams. Most of the soils of the uplands formed in loess or glacial till. Soils of association 6 formed in alluvium on bottom lands, and those in association 7 formed in alluvium or in windblown silt on low stream benches or second bottoms.

1. Marshall Association

Mostly nearly level to moderately sloping, well-drained soils on uplands

This association consists mainly of nearly level to moderately sloping, well-drained soils on broad ridgetops and generally smooth side slopes. It includes gently sloping soils in drainageways and strongly sloping to moderately steep soils on side slopes. This association makes up about 20 percent of the county. A representative area is east of Atlantic near the junction of U.S. Highways 6 and 71.

Marshall soils are dominant in this association, but minor areas of Shelby and Adair soils, of Judson-Colo complex, 2 to 5 percent slopes, and of Ladoga soils also occur. Marshall soils make up about 90 percent of the association; Shelby and Adair soils, about 2 percent; and the other minor soils, the remaining 8 percent.

The Marshall soils formed in loess under prairie grasses. They occupy all of the nearly level to moderately sloping areas on the ridgetops and most of the strongly sloping to moderately steep areas on the side slopes. These soils are deep, dark-colored silty clay loams that have good water-holding capacity and are easy to work. They are well suited to all crops commonly grown in the county, though some moderately steep or severely eroded areas are better suited to pasture than to row crops. Marshall soils are among the most productive and desirable soils in the county for farming. Response to management is good, and productivity is fairly easy to maintain. Farming on the contour and terracing will help to control loss of soil and water through erosion.

The minor Shelby and Adair soils occupy small areas generally below areas of Marshall soils. These soils are not so well drained as the Marshall soils, are lower in organic-matter content, and have seep spots in places. They generally are farmed along with the Marshall soils, but they are not so well suited to row crops.

Judson-Colo complex, 2 to 5 percent slopes, occupies areas in some of the drainageways. Judson soils are well drained or moderately well drained, and Colo soils are poorly drained. These soils, which formed in local alluvium, have good moisture holding capacity. They can be cropped fairly intensively, but they require tiling or surface drainage and protection from excessive runoff from nearby slopes. Ladoga soils formed under grasses and trees. Their acreage is small.

A large part of the soils on the farms in this association is good for crops. The farmers generally grow grain and other crops and raise beef cattle and hogs. Much of the grain is fed to the livestock.

The soils of this association generally are highly fertile, but nitrogen and phosphate fertilizers are needed if row crops are grown intensively. Most of the soils are slightly acid or medium acid and require lime. The soils on the broad, nearly level ridgetops are likely to be more acid than those in other parts of the association.

2. Marshall-Shelby-Adair Association

Mostly moderately sloping to steep, well-drained to somewhat poorly drained soils on uplands

The soils in this association are mainly on ridgetops and side slopes, though some areas are in drainageways. They are mostly moderately sloping to steep but range from nearly level to very steep. These soils make up about 26 percent of the county. A typical area is south of Atlantic near the junction of Iowa Highway 414 and U.S. Highway 71.

Dominant in this association are the Marshall, Shelby, and Adair soils. Marshall soils make up about 60 percent of the association; Shelby and Adair soils, about 20 percent; and the minor soils, about 20 percent. Minor areas consist of Judson-Colo complex, 2 to 5 percent slopes, and of Ladoga and Clarinda soils.

The Marshall soils are on the ridgetops, on the shoulders of slopes, and in places on the entire side of a slope. Adair soils occupy narrow areas on the middle part of side slopes, in coves at the heads of drainageways, and in places on the tops of extended ridges. Shelby soils generally are on the lower part of side slopes, and in the most strongly dissected areas, occupy the entire side of slopes. In many places areas of Shelby and Adair soils are intermingled in a complex pattern. Small areas of Judson-Colo complex, 2 to 5 percent slopes, are in the drainageways. The relationship of the soils to the landscape and to the parent material is shown in figure 2.

Marshall soils in this association range from nearly level to steep but are mostly moderately sloping or steeper. They are the most productive soils in this association. Use and management generally are the same as for the Marshall soils in association 1.

Shelby and Adair soils are strongly sloping to very steep. Shelby soils are well drained to moderately well drained. In uneroded areas their surface layer is dark colored and their subsoil is yellowish-brown clay loam.

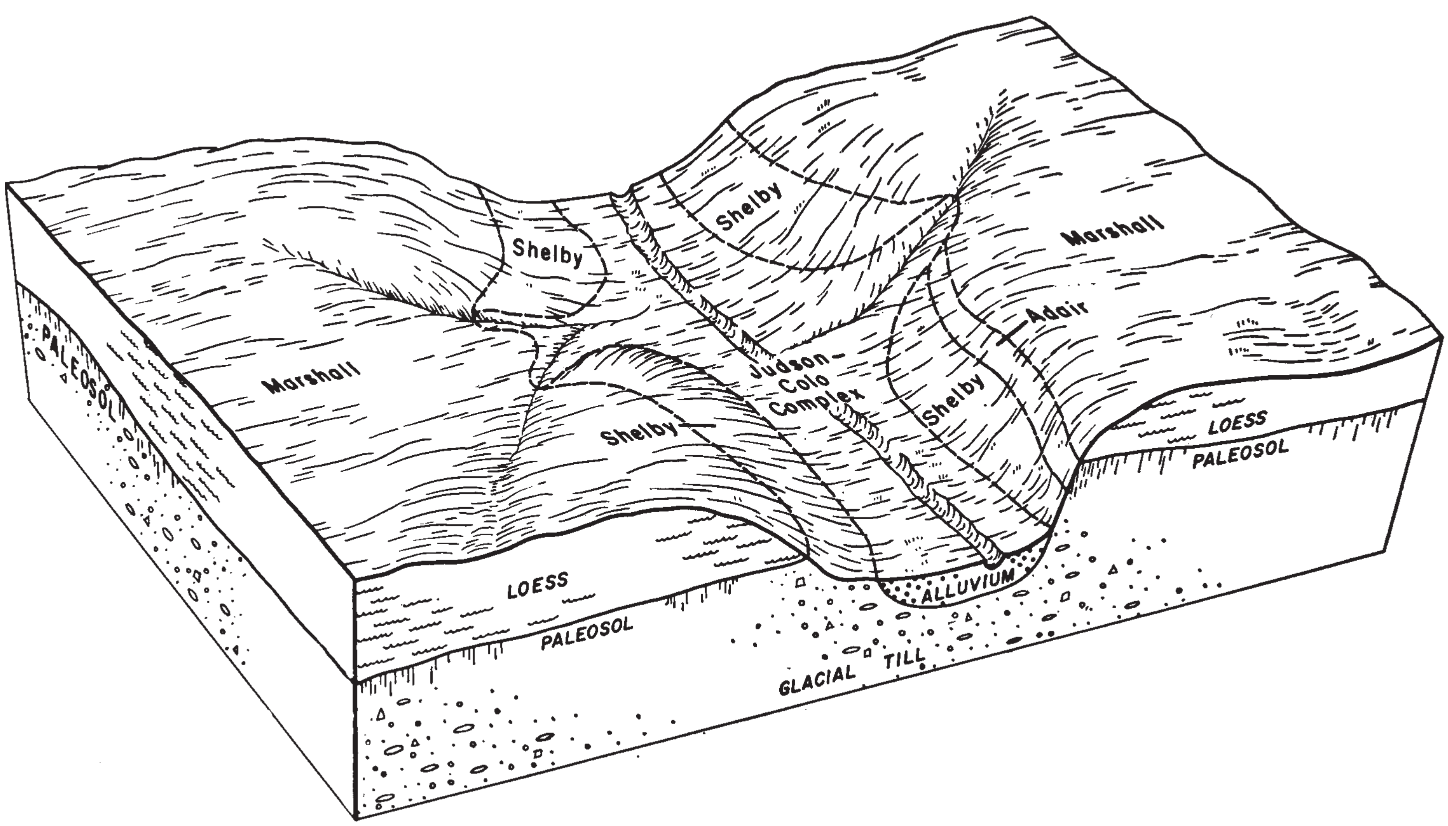

Figure 2.—**Relationship of the soils in association 2 to the landscape and to the parent material.**

The Shelby soils are less productive of row crops than the Marshall soils. Adair soils have a finer textured subsoil than have the Shelby soils. They are wet and seepy in many places in wet seasons, are somewhat poorly drained, and generally are more difficult to work than the Marshall and Shelby soils. Adair soils are poorly suited to cultivated crops. They are better suited to permanent pasture or to rotation hay and pasture than to row crops.

Of the minor soils, the Ladoga formed under grasses and trees in loess and occupy positions similar to those occupied by the Marshall soils. The Clarinda soils, which occupy positions similar to those occupied by the Adair soils, are clayey. They are seepy and wet in many places.

Most of the soils on farms in this association are suited to cultivated crops. The farmers generally raise livestock and grow grain. Raising cattle for beef is fairly extensive, and some areas of Shelby soils are in permanent pasture.

Terracing and contour farming are needed on the Marshall soils to prevent erosion and keep gullies from forming downslope in the Shelby and Adair soils. Management for the Judson-Colo complex is like that given for this complex in association 1.

The Shelby and Adair soils are less fertile than the Marshall soils and require nitrogen and phosphate. They also are typically more acid than the Marshall soils and require more lime.

3. Sharpsburg Association

Nearly level to steep, well drained or moderately well drained soils on uplands

This association consists mainly of nearly level to moderately sloping soils on ridgetops and narrow divides. It also includes strongly sloping to steep soils on side slopes that grade to gently sloping soils in drainageways. The soils make up about 11 percent of the county. A representative area is about 4 miles south of Anita along Iowa Highway 148.

Sharpsburg soils are dominant in this association, though minor areas of Ladoga soils and of Judson-Colo complex, 2 to 5 percent slopes, also occur. About 90 percent of the area consists of level to moderately sloping Sharpsburg soils. The remaining 10 percent consists chiefly of strongly sloping to steep Sharpsburg soils, though a small part is made up of minor soils.

The Sharpsburg soils formed in loess under prairie grasses. They are dark-colored, deep silty clay loams. These soils are well drained to moderately well drained and are mottled slightly higher in the subsoil than are the Marshall soils. Sharpsburg soils are on the ridgetops and divides and on side slopes above gently sloping soils of the Judson-Colo complex in drainageways. Within areas of the Sharpsburg soils are small areas of Ladoga soils.

Most of this association is used for general farm crops, though some is kept in permanent pasture. The Ladoga soils are farmed in the same way as the surrounding Sharpsburg soils. Grain and livestock are the main products, and much of the grain is fed to fatten livestock for market.

Except in eroded or steep areas, row crops are grown in crop rotation on most of the soils. The soils generally are easy to till but are likely to become hard and cloddy if cultivated when wet. If management is good, yields are favorable on most of the soils. If row crops are grown on the sloping soils, terracing and contour tillage are needed for controlling erosion and conserving moisture.

The fertility of the Sharpsburg soils is fairly high, but in intensively cropped areas nitrogen and phosphate fertilizer and barnyard manure are needed. Lime also generally is needed.

4. Sharpsburg-Shelby-Adair Association

Mostly gently sloping to steep, well-drained to somewhat poorly drained soils on uplands

The soils in this association are mainly on ridgetops and divides or on side slopes, though a few areas are in drainageways. They are mostly gently sloping to steep and are well drained to somewhat poorly drained. This association makes up about 8 percent of the county. A representative area surrounds the town of Massena.

Dominant in this association are the Sharpsburg, Shelby, and Adair soils. Sharpsburg soils make up about 60 percent of the association; Shelby and Adair soils, about 20 percent; and the minor soils, about 20 percent. Minor areas consist of Judson-Colo complex, 2 to 5 percent slopes, and of Clarinda and Ladoga soils.

The Sharpsburg soils are on the ridgetops and divides or on the upper part of side slopes, and Shelby and Adair soils are on the lower part of side slopes. Small areas of Judson-Colo complex, 2 to 5 percent slopes, are in the drainageways. Clarinda soils are mostly on the lower part of slopes or occupy many of the wet, seepy coves. Ladoga soils generally are on the upper part of side slopes. The relationship of the soils to the landscape and to the parent material are shown in figure 3.

The Shelby and Adair soils, and the minor Clarinda soils, are mostly strongly sloping to steep. The Shelby soils are easier to work than are the Adair and Clarinda soils, and crops on them respond better. In places, however, they are intermingled with Adair and Clarinda soils and cannot be cultivated separately.

Adair and Clarinda soils have high moisture-holding capacity and low fertility. They are hard when dry. Their subsoil is sticky when wet and in places is exposed. These soils also generally are eroded and are difficult to till.

Judson-Colo complex, 2 to 5 percent slopes, generally is not cropped intensively. In most areas surface drains or tile drains are needed to reduce wetness.

Part of this association is in permanent pasture because the areas are steep and consist mostly of soils on glacial till that are not well suited to row crops. Only when reseeding or renovating pastures or meadows are some of the areas used for row crops. Nearly all of the Sharpsburg and Ladoga soils are used for cultivated crops. In this association grain and livestock are the main products.

All of the soils in this association need nitrogen and phosphate fertilizer. Most of the soils also require lime.

5. Shelby-Adair Association

Mostly strongly sloping to steep, well-drained to somewhat poorly drained soils on uplands

The soils in this association are mostly in strongly sloping to steep, fairly dissected areas and are well drained to somewhat poorly drained. This association makes up

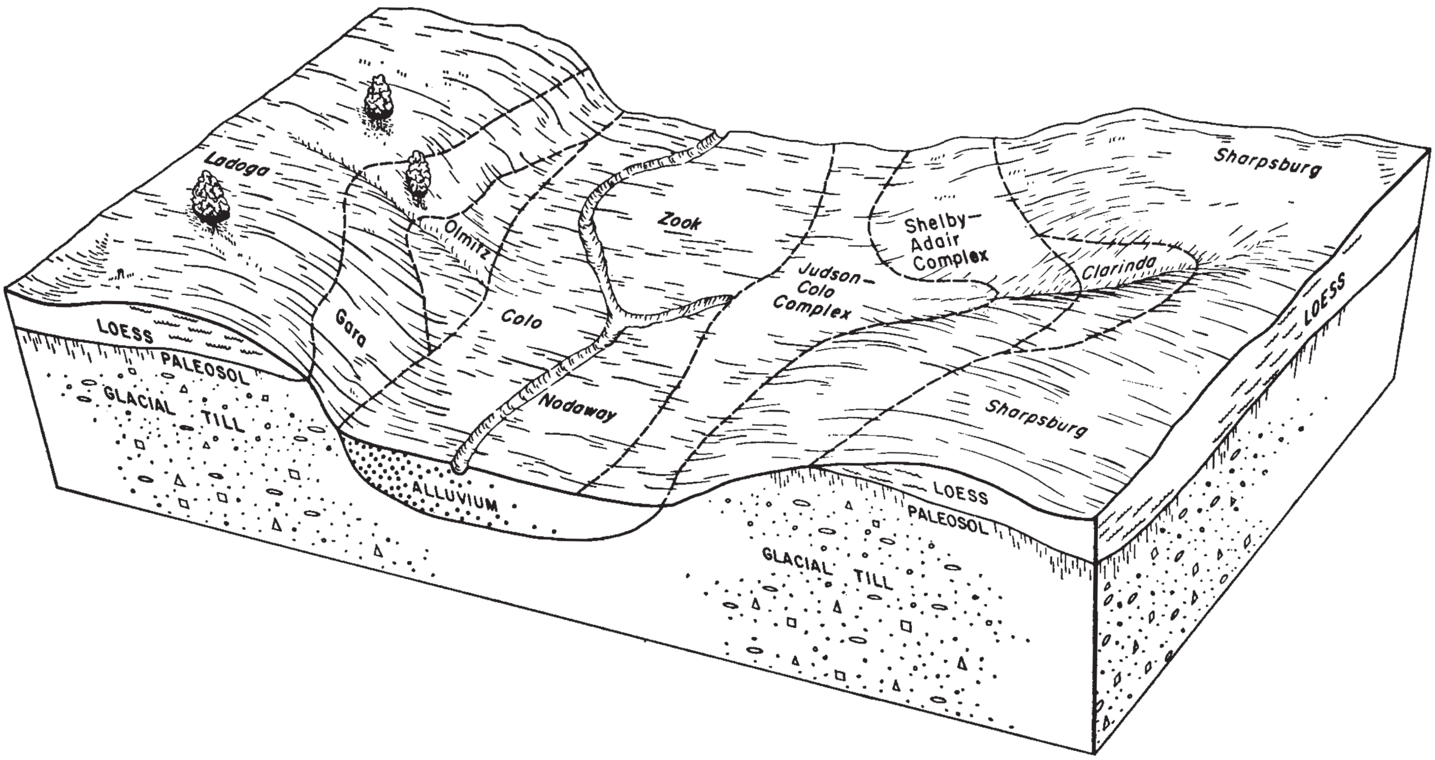

Figure 3.—**Relationship of the soils in association 4 to the landscape and to the parent material.**

about 21 percent of the county. A typical area is just across Turkey Creek, south of Anita.

Shelby and Adair soils are dominant in this association, though minor areas of other soils occur. The Shelby and Adair soils and the minor Clarinda soils make up about 60 percent of the association. Small areas of Marshall and Sharpsburg soils, of Judson-Colo complex, 2 to 5 percent slopes, and of the less extensive Kennebec, Ladoga, and Nodaway soils occupy the remaining 40 percent.

The Shelby and Adair soils and the Clarinda soils are on the lower part of slopes on glacial till. These soils are used mainly for hay and pasture, though trees grow in thin stands in some places. They are not suited to row crops, because their fertility is low and they are difficult to till.

The gently sloping to moderately sloping Ladoga, Marshall, and Sharpsburg soils formed in loess on ridgetops just above the Shelby and Adair soils and the Clarinda soils. They are well suited to cultivated crops but require good management to keep soil losses within allowable limits.

The Colo and Judson soils are in narrow drainageways, and the Kennebec, Nodaway, and Zook soils are on narrow bottom lands. All of these soils occupy areas just below Shelby and Adair soils and the Clarinda soils and are highly productive.

Most of the farming in this association is diversified. Grain and livestock raised for beef are the main products, though the areas are also suited to dairy farming. Most of the grain is fed to the livestock, and additional grain would need to be purchased to increase beef production unless the farms were enlarged.

Additions of nitrogen and phosphate are beneficial for hay and pasture crops, as well as for cultivated crops. Most of the soils are acid and require lime.

6. Nodaway-Zook-Colo Association

Nearly level, moderately well drained to poorly drained soils on bottom lands

The soils in this association are nearly level and are mostly on bottom lands, though small areas are on low benches. They are moderately well drained to poorly drained. This association occupies 10 percent of the county. A typical area is northwest of Atlantic along the East Nishnabotna River.

Nodaway, Zook, and Colo soils are dominant in this association, but minor areas of Kennebec and Wabash soils also occur. Nodaway soils make up about 30 percent of the association; Zook soils, about 20 percent; Colo soils, about 20 percent; and the minor soils, the remaining 30 percent.

The Nodaway soils are near stream channels throughout the county. They are moderately dark colored to light colored and are medium textured. They are somewhat poorly drained to moderately well drained and can be used intensively for crops. The content of organic matter is moderately low, but the soils are easy to work and respond well to good management. They are the most productive soils in the association and do not require special practices.

Zook soils are dark colored. Their content of organic matter is high. They have a fine-textured subsoil and are poorly drained to very poorly drained. Zook soils generally stay wet later in spring than Nodaway soils. If they are worked early in spring when wet, they puddle and then become cloddy when dry. If tile is used to provide drainage, it should be spaced closer than in coarser textured soils and placed at a shallower depth.

Colo soils are dark colored, are poorly drained, and have a moderately fine textured subsoil. They are highly productive if drainage is provided. Tile generally can be used to provide drainage if outlets are available.

The minor Kennebec soils occupy areas similar to those occupied by the Nodaway soils. They are dark colored but otherwise are similar to the Nodaway soils and are used and managed the same. Wabash soils are fine textured throughout. They have a high content of organic matter, but they are very poorly drained and therefore are poor for farming. Tillage often is delayed because the areas remain wet until late in spring. Tile drains do not work in the Wabash soils, but surface drains can be used in places.

Most of the acreage in crops on farms in this association is used for row crops. Areas in permanent pasture are near old stream channels or oxbows and are flooded frequently. The farmers generally grow grain as a cash crop, but some of the grain is fed to livestock. The Zook, Colo, and Wabash soils generally occupy areas that are farther away from the stream channels than the Nodaway and Kennebec soils. They are subject to flooding in some places, particularly in low areas, and open ditches are needed in many places to provide drainage. On these soils soybeans and wheat are grown in many places.

The soils in this association are highly fertile. If they are cropped intensively, however, nitrogen and phosphate fertilizer are needed.

7. Marshall-Bremer-Nevin Association

Nearly level, well-drained to poorly drained soils on benches

This soil association consists of nearly level, well-drained to poorly drained soils on benches. The areas are

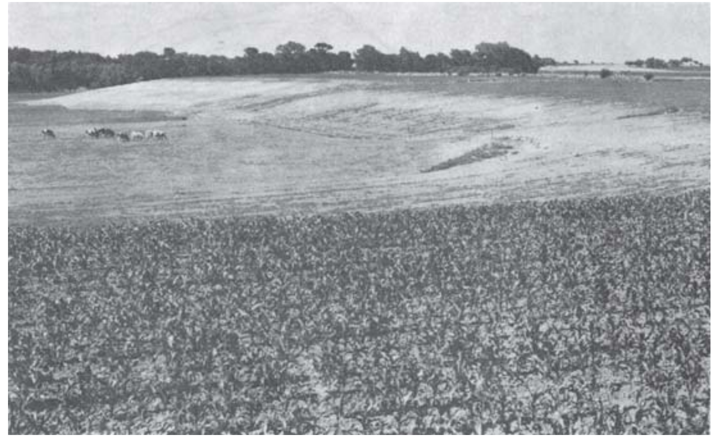

***Figure 4.*—Representative area of soils of the Marshall-Bremer-Nevin association in the foreground and upper right on low benches. An eroded escarpment separates the areas from the bottom lands where cattle are grazing.**

mainly along the East Nishnabotna River, but small areas are along other streams in the county. The association occupies about 4 percent of the county. A representative area is 2 miles north of Griswold (fig. 4).

Dominant in this association are the Marshall, Bremer, and Nevin soils. Marshall soils make up about 45 percent of the association; Bremer soils, about 20 percent; Nevin soils, about 10 percent; and the minor soils, the remaining 25 percent. Minor areas are made up of Colo, Corley, Humeston, Minden, and Wabash soils. The relationship of the soils in association 7 to the landscape and the parent material are shown in figure 5.

Marshall soils, the most extensive in this association, formed in loess underlain by old alluvium. The alluvium

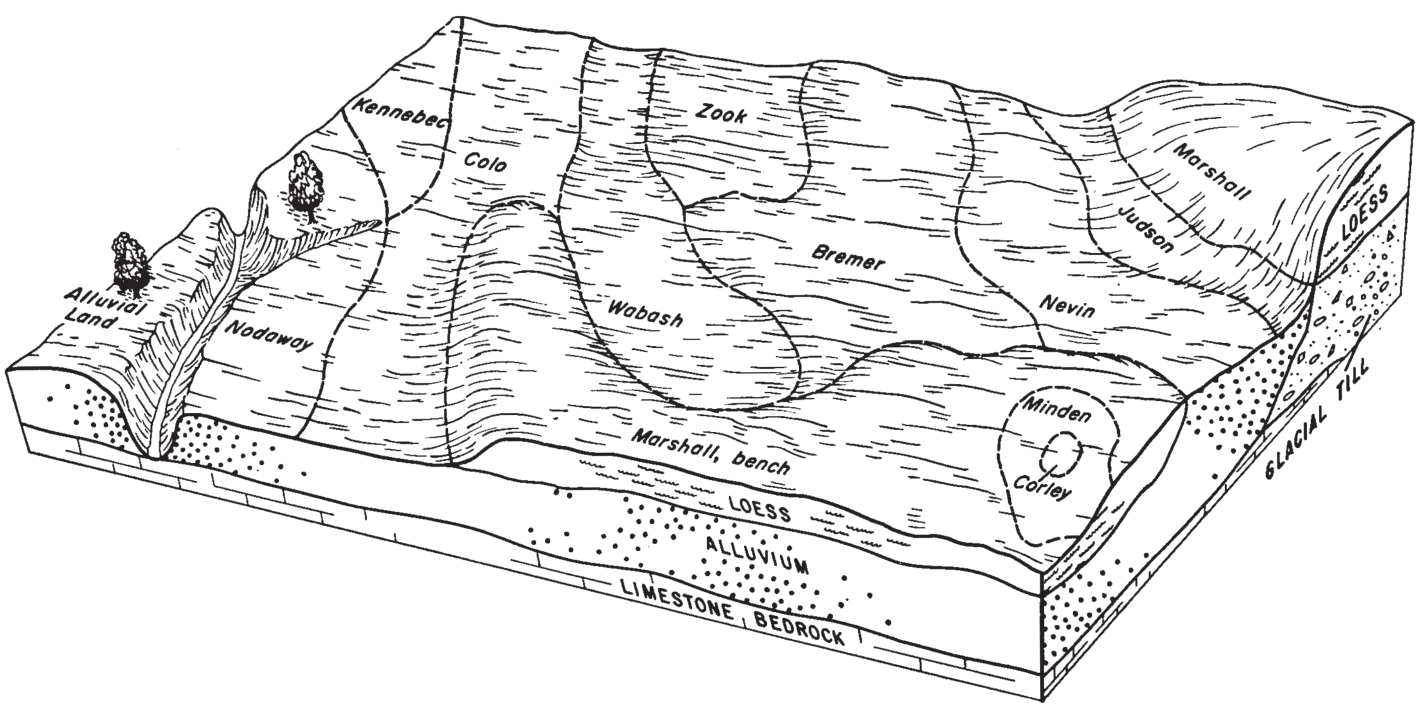

***Figure 5.*—Relationship of the soils in association 7 to the landscape and the parent material.**

consists of stratified silt and sand and is at a depth between 10 and 20 feet. These soils are used and managed about the same as those Marshall soils in the uplands having similar slopes (see association 1).

The Bremer and Nevin soils formed in alluvium. They have a dark-colored surface layer and are high in organic matter. Bremer soils are poorly drained and are moderately fine textured to fine textured. Nevin soils are somewhat poorly drained and are moderately fine textured. The water table is high in both of these soils during wet seasons. Bremer soils need artificial drainage.

Drainage is the main factor limiting use of the Colo soils for crops. These soils are used and managed the same as the Colo soils in the Nodaway-Zook-Colo association.

Small areas of Corley, Humeston, and Minden soils generally are within areas of the Marshall soils in shallow depressions. Water tends to pond on these soils after rains. Open surface drainage is beneficial if outlets are provided.

The minor Wabash soils occupy low benches in this association. These soils are very poorly drained, have a high content of clay in the surface layer and subsoil, and are in poor tilth. They are better suited to wheat and soybeans than to other cultivated crops. Tile drains do not work well in these soils, but surface drainage is beneficial if outlets are available.

All of the soils in this association require good management, and except for Marshall soils, they generally require artificial drainage. In many places outlets are difficult to obtain because of the distance from the main channel of a stream.

Most of the acreage in this association is used for cultivated crops. Some of the wet areas are difficult to drain and are used as permanent pasture. On most of the farms grain is grown as a cash crop or grain and livestock are the main products. Two or three large farms have purebred herds of beef cattle. A livestock research farm is in this association near Atlantic.

If the soils in this association are cropped intensively, nitrogen and phosphate fertilizers are needed. Most of the soils also require lime.

Descriptions of the Soils

This section describes the soil series and mapping units of Cass County. The acreage and proportionate extent of each mapping unit are given in table 1. Their location in the county is shown on the detailed soil map at the back of this survey.

The procedure is first to describe the soil series, and then the mapping units in that series. Thus, to get full information on any mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Alluvial land, for example, is a miscellaneous land type that does not belong to a soil series. It is listed, nevertheless, in alphabetic order along with the soil series. Described along with some mapping units are small areas of contrasting soils. Special symbols used to locate such soils on the map are shown in the legend to the detailed soil map.

In comparing a mapping unit with a soil series, many will prefer to read the short description in paragraph form. It precedes the technical description that identifies layers by A, B, and C horizons and depth ranges. The technical profile descriptions are mainly for soil scientists, engineers, and others who need to make a more thorough and precise study of the soils.

In describing the representative profile, the color of each horizon is described in words, such as yellowish brown, but it can also be indicated by symbols for the hue, value, and chroma, such as 10YR 5/4. These symbols, called Munsell color notations (*27*),[2] are used by soil scientists to evaluate the color of the soil precisely. For the profiles described, the names of the colors and the color symbols are for moist soil unless stated otherwise.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The page on which each capability unit is described can be found by referring to the "Guide to Mapping Units" at the back of this survey. Many terms in the soil descriptions and in other parts of this survey are defined in the Glossary. Predicted yields for all of the soils are given in table 2.

Adair Series

In the Adair series are dark colored or moderately dark colored, moderately well drained to somewhat poorly drained soils. These soils formed under prairie grasses in reddish, fine-textured horizons of old glacial till soils called paleosols, which formed during an earlier geologic period and were later buried under loess. The Adair soils formed after the buried soils were exposed by geologic erosion.

The Adair soils are in the uplands in narrow areas around side slopes, in coves at the heads of drainageways, and in many places on the tops of long ridges. Slopes range from 5 to 18 percent. Adair soils occur throughout the county. The largest areas, however, are in the western part in the more rolling tracts just east of the East Nishnabotna River, or are in the eastern two-thirds of the county. Adair soils are near the Clarinda, Ladoga, Marshall, Sharpsburg, and Shelby soils.

The surface layer is very dark brown and very dark grayish-brown, friable light clay loam to light gritty silty clay loam. It has fine subangular blocky structure and is about 8 inches thick. The subsoil extends to a depth of about 50 inches and has subangular blocky structure. It is dark grayish-brown, friable to firm light clay loam in the upper part. The middle part is dark-brown, firm light clay with many red, strong-brown, and yellowish-red mottles. The lower part is yellowish-red and red, very firm clay loam with many brownish-gray and grayish-brown mottles.

Adair soils have high available moisture capacity and medium to low content of organic matter. Permeability is very slow. These soils are low to very low in available nitrogen and phosphorus and medium to low in available potassium. They are medium acid in most places. Adair soils typically are seasonably wet and seepy in areas near their boundary with soils upslope that are derived from loess.

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[2] Italic numbers in parentheses refer to Literature Cited, p. 78.

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

Soil	Acres	Percent
Adair clay loam, 5 to 9 percent slopes, moderately eroded	1, 806	0. 5
Adair clay loam, 9 to 14 percent slopes	852	. 2
Adair clay loam, 9 to 14 percent slopes, moderately eroded	11, 445	3. 2
Adair clay loam, 14 to 18 percent slopes, moderately eroded	594	. 2
Adair soils, 5 to 9 percent slopes, severely eroded	255	. 1
Adair and Shelby soils, 9 to 14 percent slopes, severely eroded	4, 385	1. 2
Adair and Shelby soils, 14 to 18 percent slopes, severely eroded	2, 612	. 7
Alluvial land	530	. 1
Ankeny fine sandy loam	119	(1)
Bremer silty clay loam	1, 154	. 3
Calco silty clay loam	94	(1)
Clarinda silty clay loam, 5 to 9 percent slopes	317	. 1
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	899	. 3
Clarinda silty clay loam, 9 to 14 percent slopes	135	(1)
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	1, 419	. 4
Clarinda soils, 5 to 18 percent slopes, severely eroded	596	. 2
Colo silty clay loam	2, 662	. 7
Colo silt loam, overwash	3, 018	. 8
Colo-Nodaway complex	1, 938	. 5
Corley silt loam, 0 to 2 percent slopes	135	(1)
Gara loam, 9 to 14 percent slopes	226	. 1
Gara loam, 9 to 14 percent slopes, moderately eroded	279	. 1
Gara loam, 14 to 18 percent slopes	343	. 1
Gara loam, 14 to 18 percent slopes, moderately eroded	681	. 2
Gara loam, 18 to 25 percent slopes, moderately eroded	182	. 1
Gara soils, 14 to 18 percent slopes, severely eroded	193	. 1
Hagener soils, 9 to 18 percent slopes, moderately eroded	422	. 1
Humeston silt loam	159	(1)
Judson silt loam, 0 to 2 percent slopes	3, 392	1. 0
Judson silt loam, 2 to 5 percent slopes	13, 422	3. 8
Judson silt loam, 5 to 9 percent slopes	473	. 1
Judson-Colo complex, 2 to 5 percent slopes	58, 848	16. 4
Kennebec silt loam	2, 400	. 7
Ladoga silt loam, 2 to 5 percent slopes	987	. 3
Ladoga silt loam, 5 to 9 percent slopes	631	. 2
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	1, 683	. 5
Ladoga silt loam, 9 to 14 percent slopes	509	. 1
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	2, 343	. 7
Ladoga silt loam, 14 to 18 percent slopes	332	. 1
Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	839	. 2
Ladoga silt loam, benches, 2 to 5 percent slopes	343	. 1
Ladoga soils, 9 to 14 percent slopes, severely eroded	415	. 1
Ladoga soils, 14 to 18 percent slopes, severely eroded	281	. 1
Marsh	405	. 1
Marshall silty clay loam, 0 to 2 percent slopes	2, 553	. 7
Marshall silty clay loam, 2 to 5 percent slopes	28, 434	7. 9
Marshall silty clay loam, 5 to 9 percent slopes	6, 536	1. 8
Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	21, 486	6. 0
Marshall silty clay loam, 5 to 9 percent slopes, severely eroded	949	. 3
Marshall silty clay loam, 9 to 14 percent slopes	3, 816	1. 1
Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	39, 666	11. 1
Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	3, 163	. 9
Marshall silty clay loam, 14 to 18 percent slopes, moderately eroded	2, 947	. 8
Marshall silty clay loam, 14 to 18 percent slopes, severely eroded	1, 037	. 3
Marshall silty clay loam, benches, 0 to 2 percent slopes	3, 247	. 9
Marshall silty clay loam, benches, 2 to 5 percent slopes	2, 704	. 8
Marshall silty clay loam, benches, 5 to 9 percent slopes, moderately eroded	928	. 3
Minden silty clay loam, benches	1, 132	. 3
Nevin silty clay loam	2, 390	. 7
Nodaway silt loam	10, 230	2. 9
Nodaway silt loam, channeled	2, 463	. 7
Olmitz loam, 2 to 5 percent slopes	540	. 1
Sandstone rock land	89	(1)
Sharpsburg silty clay loam, 0 to 2 percent slopes	1, 751	. 5
Sharpsburg silty clay loam, 2 to 5 percent slopes	13, 510	3. 8
Sharpsburg silty clay loam, 5 to 9 percent slopes	3, 231	. 9
Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	17, 298	4. 8
Sharpsburg silty clay loam, 9 to 14 percent slopes	1, 408	. 4
Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	13, 226	3. 7
Sharpsburg silty clay loam, 9 to 14 percent slopes, severely eroded	691	. 2
Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded	566	. 1
Sharpsburg silty clay loam, 14 to 18 percent slopes, severely eroded	452	. 1
Shelby loam, 5 to 9 percent slopes, moderately eroded	462	. 1
Shelby loam, 9 to 14 percent slopes	795	. 2
Shelby loam, 9 to 14 percent slopes, moderately eroded	4, 260	1. 2
Shelby loam, 14 to 18 percent slopes	1, 278	. 3
Shelby loam, 14 to 18 percent slopes, moderately eroded	4, 024	1. 1
Shelby loam, 18 to 25 percent slopes, moderately eroded	759	. 2
Shelby soils, 9 to 14 percent slopes, severely eroded	1, 242	. 3
Shelby soils, 14 to 18 percent slopes, severely eroded	1, 533	. 4
Shelby soils, 18 to 30 percent slopes, severely eroded	628	. 2
Shelby-Adair complex, 5 to 9 percent slopes, moderately eroded	283	. 1
Shelby-Adair complex, 9 to 14 percent slopes	769	. 2
Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded	9, 947	2. 8
Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded	4, 888	1. 4
Shelby-Adair complex, 18 to 25 percent slopes, moderately eroded	375	. 1
Shelby-Adair complex, 18 to 30 percent slopes, severely eroded	504	. 1
Wabash silty clay	2, 423	. 7
Wabash silty clay loam	1, 262	. 4
Zook silty clay loam	5, 512	1. 5
Zook silt loam, overwash	2, 026	. 6
Quarries, metropolitan, and miscellaneous	2, 912	. 8
Water	681	. 2
Total	357, 760	100. 0

[1] Less than 0.05 percent.

Representative profile of Adair clay loam on a slightly concave slope of 10 percent that faces east and is moderately eroded (75 feet north and 100 feet east of the southwest corner of the SE¼SW¼ sec. 33, T. 76 N., R. 35 N.) :

Ap—0 to 8 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) light clay loam to light gritty silty clay loam that is very dark grayish brown (10YR 3/2) when kneaded; cloddy but breaks to fine granular structure in the upper 3 inches and medium, fine, subangular blocky structure below; friable; a few, fine, distinct mottles of strong brown (7.5YR 5/6) in the lower 2 inches; common to many very fine pores; medium acid; abrupt boundary.

B1—8 to 16 inches of light clay loam that is mostly dark grayish brown (10YR 4/2) but is 30 percent dark brown to brown (10YR 4/3) ; a few, fine, distinct mottles of strong brown (7.5YR 5/8) ; moderate, fine and medium, subangular blocky structure; friable to firm; very thin, discontinuous clay films in the lower part; many, very fine tubular pores within peds; many, fine, soft oxide concretions; medium acid; clear boundary.

IIB21t—16 to 20 inches, dark-brown to brown (7.5YR 4/4) light clay; common, medium, prominent mottles of light olive brown (2.5Y 5/4) to grayish brown (2.5Y 5/2) and many, medium, prominent mottles of strong brown (7.5YR 5/8) and yellowish red (5YR 4/8) ; strong, medium, subangular blocky structure; firm; continuous clay films on vertical faces; a few soft oxide concretions; many small and fine pebbles indicate a stone line; medium acid; clear boundary.

IIB22t—20 to 31 inches, dark-brown to brown (7.5YR 4/4) and brown (7.5YR 5/4) light clay; many, medium, prominent mottles of red (2.5YR 4/8) and common, medium, distinct mottles of yellowish red (5YR 5/6) and light reddish brown (5YR 6/4) ; strong, medium, subangular blocky structure; very firm; many, thick, continuous clay films on ped faces; a few fine oxide concretions; fragments of very fine gravel are more common than in the IIB21t horizon; medium acid; gradual boundary.

IIB23t—31 to 42 inches, strong-brown (7.5YR 5/8) and red (2.5YR 4/8) heavy clay loam; many, coarse, prominent mottles of light brownish gray (2.5Y 6/2) and grayish brown (2.5Y 5/2) ; moderate, coarse, subangular blocky structure; very firm; many, thin, discontinuous clay films on ped faces; soft oxide concretions and some fine pebbles; medium acid; gradual boundary.

IIB3—42 to 50 inches, light clay loam but otherwise similar to the material in the IIB23t horizon.

The surface layer ranges from light clay loam to light silty clay loam in texture, depending on the degree of slope and the amount of erosion that has taken place. This layer ranges from black to very dark grayish brown in color and is 6 to 14 inches thick. The subsoil is brown to strong brown or reddish brown, has reddish mottles, and is 40 to 45 percent clay where the texture is finest. Except in eroded areas, a layer of pebbles generally is in the upper part of the subsoil. The subsoil typically is between 36 and 48 inches thick and is underlain by yellowish-brown to olive-brown, mottled clay loam.

Adair soils are not so clayey as the Clarinda soils, and they have more sand and gravel in their surface layer and subsoil and a reddish, rather than gray, subsoil. Their subsoil is redder, more clayey, and firmer than that in the associated Shelby soils.

Adair clay loam, 5 to 9 percent slopes, moderately eroded (AdC2).—This soil occupies narrow areas on short side slopes or is on long ridges below soils formed in loess. Many areas are on slopes above drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes, and some areas occupy slopes above areas of Shelby soils. The areas generally are between 5 and 25 acres in size and are widely scattered throughout the county.

The surface layer of this soil generally is slightly thicker than that in the profile described as representative for the series. Also, areas that have less than 3 inches of the original surface layer remaining are less extensive than in Adair clay loam, 9 to 14 percent slopes, moderately eroded. In places the surface layer ranges from 7 to 12 inches in thickness, and these areas generally are pastured.

Many areas of this soil are in cultivated crops, but some areas are in pasture. This soil is not well suited to cultivation but generally is farmed along with adjacent, more permeable soils.

If this soil is used for row crops, contour tillage is needed. Further erosion can be prevented and gullies kept from forming by placing terraces above this soil in soils more suitable for terrace construction. In many places seepage spots occur, but their wetness can be reduced by placing interceptor tile upslope in the more permeable soils. Capability unit IIIe-2.

Adair clay loam, 9 to 14 percent slopes (AdD).—This soil generally occupies narrow areas on side slopes, but in some places it is on long ridges. It is downslope from less sloping Ladoga, Marshall, and Sharpsburg soils and generally is upslope from Shelby soils. The areas of this soil range from about 5 to 30 acres in size, and they occur throughout the county.

The surface layer of this soil is black or very dark gray clay loam 10 to 14 inches thick. In small areas less than 3 inches of the original surface layer remains, and these areas are shown on the soil map by the symbol for severe erosion. This soil is subject to erosion through runoff if the surface is not protected. It is likely to seal over if it is tilled when wet and to become hard and cloddy as it dries.

Included with this soil are some areas that have about 30 inches of silty material overlying the fine-textured, reddish subsoil. These areas are too small to be mapped separately.

This Adair soil is better suited to semipermanent hay or pasture crops than to row crops, and many areas are in pasture. It can be used occasionally for row crops. In many areas it is used for row crops along with adjacent soils that are better suited to row crops. If this soil is cultivated, contour tillage is needed. Areas that are wet because of seepage can be protected by placing interceptor tile in areas just above this soil. Gullies in the sides of slopes ought to be filled and shaped and then stabilized by seeding grass. Capability unit IVe-2.

Adair clay loam, 9 to 14 percent slopes, moderately eroded (AdD2).—Most areas of this soil are just below areas of the Sharpsburg and Marshall soils. Some areas, however, are just below the Clarinda soils, and some are upslope from the Shelby soils. In a few places this soil lies just above the Marshall and Sharpsburg soils. In many areas this soil is intermingled with the Shelby soils and is mapped in a complex with them. Areas of this soil are scattered throughout the county, and most of them are between 5 and 30 acres in size.

This is the most extensive Adair soil in the county, and its profile is like the one described as representative for the series. In some small areas the surface layer is dark colored and silty and is 10 to 12 inches thick. In some severely eroded areas, the plow layer consists of brown material formerly in the subsoil; these areas are too small to be mapped separately.

This soil is better suited to hay and pasture than to row crops, though row crops can be grown occasionally. In many places it is used for row crops because it occurs in relatively small areas with soils that are better suited to row crops.

If this soil is farmed along with soils that are better suited to farming, practices that control erosion and that keep fertility high are especially needed. Gullies that commonly form in side slopes can be shaped, seeded, and used as waterways. A way to control erosion and prevent gullying is placing terraces in areas just above this soil, in soils more suitable for terrace construction. Wetness caused by seepage can be reduced by placing terraces in areas just above this soil and using interceptor tile. Capability unit IVe–2.

Adair clay loam, 14 to 18 percent slopes, moderately eroded (AdE2).—This soil generally is on side slopes that in many places are less than 150 feet wide. The areas are between the higher lying Marshall and Sharpsburg soils and the lower lying Shelby soils. In many places, however, this soil is adjacent to soils that are in narrow drainageways or on bottom lands. Areas of this soil are about 5 to 20 acres in size and are scattered throughout the county, especially in dissected areas along the major streams and their tributaries.

The surface layer of this soil is dominantly 3 to 7 inches thick but in about 10 percent of the areas it is between 10 and 14 inches thick. In severely eroded areas, the surface layer generally contains gravel or small stones.

Included with this soil are small areas of a soil that has a surface layer that is less than 3 inches thick. Also included are a few areas of a soil that has a surface layer of silty clay loam.

Because of the clayey subsoil and steep slopes, runoff is rapid on this Adair soil. This soil therefore is subject to severe erosion and is not suited to cultivation. It is best left in permanent pasture. Yields of forage can be increased if fertilizer and manure are added and if the pastures are renovated. Capability unit VIe–2.

Adair soils, 5 to 9 percent slopes, severely eroded (ArC3).—These undifferentiated soils generally are on the sides of long, narrow ridges just below Sharpsburg or Marshall soils, on gently sloping ridgetops, and just above the Shelby soils. The areas generally are between 5 and 20 acres in size and occur in all parts of the county.

The surface layer is brown or dark-brown clay loam or light clay that is 3 inches or less in thickness. Because of erosion the subsoil is exposed, and tilth of these soils is poor. The surface soil is sticky and plastic when wet, and it becomes hard and cloddy when dry and subject to cracking. In places small areas of Clarinda soils occur within areas of this soil, and these are shown on the soil map by the clay spot symbol.

These Adair soils are poorly suited to row crops. They are difficult to work, are low in organic matter and fertility, and absorb moisture slowly. Growing of row crops should be done only when establishing a stand of hay or renovating a pasture. Then, contour tillage is needed.

Runoff causes less erosion if gullies are filled and seeded to grass for use as waterways. The sodded waterways also provide a crossing for tillage implements. Wet, seepy areas at the upper edges of these soils can be partly dried by placing interceptor tile in areas just above these soils. Farming on the contour and placing terraces just above these soils in the Ladoga, Marshall, or Sharpsburg soils provide protection from erosion while cover is being established. Adding manure and fertilizer helps to improve soil tilth and increase productivity. Capability unit IVe–2.

Adair and Shelby soils, 9 to 14 percent slopes, severely eroded (AsD3).—Many areas of these soils are narrow and are on side slopes or in coves at the heads of drainageways just above Judson and Colo soils in the drainageways. Some areas are just below gently sloping or moderately sloping Marshall and Sharpsburg soils on ridgetops, and some are just above Adair and Shelby soils, 14 to 18 percent slopes, severely eroded, or are just above steeper Shelby soils. The areas occur throughout the county and generally are between 5 and 40 acres in size.

The surface layer is 3 inches or less thick and is variable in color. It generally is clay loam in the Shelby soils and clay loam or clay in the Adair soils. As the result of erosion, the subsoil of firm clay loam and clay is exposed, and in many places stones and pebbles are on the surface.

These soils are not suited to row crops, and most areas have a cover of permanent vegetation. The content of organic matter is quite low, tilth is poor, and yields are low. It is difficult to cultivate these soils or to prepare a seedbed in them. The soils become cloddy if worked when wet, and they harden and crack deeply when they dry. Many areas on the side slopes are cut by gullies that cannot be crossed with farm machinery.

Under good management, including pasture renovation, forage crops grow well. Gullies in these soils need to be shaped and seeded to grass for use as waterways. Protection from further erosion is provided by terracing and contour farming just above these soils in soils that are used for row crops. Interceptor tile reduces seepage that makes these soils wet in many places. Capability unit VIe–2.

Adair and Shelby soils, 14 to 18 percent slopes, severely eroded (AsE3).—These soils are downslope from Adair and Shelby soils, 9 to 14 percent slopes, severely eroded and from the Marshall and Sharpsburg soils on the ridgetops. In many places they occupy side slopes just above Judson and Colo soils in drainageways. In some places they adjoin Shelby soils on similar slopes. Individual areas are between 5 and 40 acres in size.

All except 3 inches or less of the original surface layer of these soils has been removed through erosion. The present surface layer is loam to clay loam in the Shelby soils and clay loam to clay in the Adair. In many places stones and pebbles are on the surface.

Because of severe sheet and gully erosion, these soils are not suited to cultivated crops. Tilth is poor, fertility is low, and the capacity to absorb moisture is poor. These soils are moderately well suited to pasture, but overgrazing must be avoided. Renovation of the pastures generally is needed, but it is difficult because of the many gullies. The gullies can be shaped and seeded to grass for use as waterways. Terracing the soils that are upslope helps to divert runoff and to control further erosion and gullying. Capability unit VIIe–1.

Alluvial Land

Alluvial land (Au) consists of areas of unconsolidated alluvium recently deposited on first bottoms of major streams in the county. The material varies widely in color and texture and is distinctly stratified. Most areas are poorly drained or very poorly drained. The areas are undulating, are frequently flooded, and are subject to change by deposition. They generally are between 20 and 60 acres in size.

In general, Alluvial land consists of light-colored deposits of silt and sand mixed with dark-colored layers of clayey materials. Sediment of silt or sand is laid down on the areas each year when the streams overflow.

Included with this land type in mapping are many areas of Nodaway soils that are too small to be mapped separately.

Much of Alluvial land is wooded and cut by shallow, old meanders and oxbows. Some of the old channels are filled with water and cannot be crossed with farm machinery. Other areas have a cover of willow and cottonwood saplings and are wet for long periods.

Alluvial land has limited value for farming if it is not cleared, smoothed, and drained. At present it provides pasture in some areas and is used as habitats for wildlife. Capability unit IIIw-1.

Ankeny Series

The Ankeny series consists of dark-colored, well-drained to somewhat excessively drained soils. These soils formed chiefly under prairie grasses in sandy alluvium on nearly level, low benches. They generally are along the East Nishnabotna River between soils formed in loess on higher lying stream benches and lower lying areas of Alluvial land and Nodaway, Kennebec, and other soils on first bottoms.

The surface layer is friable or very friable fine sandy loam about 20 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. Structure ranges from fine granular to fine subangular blocky. The subsoil extends to a depth of about 40 inches and is dark-brown, very friable fine sandy loam that has weak or very weak subangular blocky structure. The substratum is dark-brown to brown sandy loam or loamy sand.

These soils are droughty and are subject to soil blowing. They have low available water capacity and moderately low content of organic matter. Permeability of the subsoil is moderately rapid. Ankeny soils are low in available nitrogen and phosphorus, low to medium in potassium, and slightly acid to neutral.

Representative profile of Ankeny fine sandy loam on a low, nearly level, alluvial bench (50 feet north of the center of the road in the southwest corner of the NE¼NE¼ of sec. 30, T. 75 N., R. 37 W.):

Ap—0 to 7 inches, very dark brown (10YR 2/2) fine sandy loam; weak, very fine, granular structure; very friable; very porous; neutral; abrupt boundary.

A12—7 to 13 inches, very dark brown (10YR 2/2) fine sandy loam; very weak, fine, angular blocky structure; friable; porous; contains slightly more silt than the Ap horizon; neutral; clear boundary.

A3—13 to 20 inches, very dark grayish-brown (10YR 3/2) light sandy loam; very weak, subangular blocky structure; very friable; porous; neutral; clear boundary.

B1—20 to 27 inches, dark-brown (10YR 3/3) fine sandy loam; very dark grayish-brown (10YR 3/2) ped exteriors; weak, fine, subangular blocky structure; very friable; porous; neutral; gradual boundary.

B2—27 to 40 inches, dark-brown (10YR 3/3) fine sandy loam; very dark grayish-brown (10YR 3/2) ped exteriors; very weak, fine, subangular blocky structure; very friable; very porous; neutral.

The surface layer ranges from very dark brown to very dark grayish brown in color and from about 18 to 24 inches in thickness. The subsoil generally is dark brown, but it grades to dark brown or brown as depth increases and in places is very dark grayish brown in the upper part. The surface layer and subsoil are fine sandy loam throughout; their combined thickness generally is between 36 and 48 inches. In some places the texture of the substratum is loamy sand.

Ankeny soils are dark colored to a greater depth than Hagener soils, and their subsoil and underlying material are less sandy.

Ankeny fine sandy loam (0 to 2 percent slopes) (Ay).—This is the only Ankeny soil mapped in the county. It occupies a few scattered areas on low stream benches of the East Nishnabotna River in the western part of the county. The profile is like the one described as representative for the series.

This soil is easy to work and is suited to cultivated crops, though yields are limited because of droughtiness. Most areas are used for row crops, and some of them are large enough to farm separately. Leaving crop residues on the surface helps to reduce soil blowing. Crops on this soil respond if manure and fertilizer are added and if sufficient moisture is available. Capability unit IIIs-1.

Bremer Series

In the Bremer series are nearly level, dark-colored, poorly drained soils on low benches or second bottoms. These soils formed under prairie grasses in silty alluvium. In places they are on broad second bottoms that grade toward the first bottoms, and here they are associated with Colo, Corley, Judson, Nevin, Wabash, and Zook soils. They also are in depressional areas on high stream benches near the Marshall and Minden soils. Bremer soils, are mostly along the East Nishnabotna River, but small areas are along some of the smaller tributaries in the county.

The surface layer is black, friable to firm silty clay loam that has very fine and fine subangular blocky structure and is about 20 inches thick. The subsoil extends to a depth of about 42 inches and has subangular blocky structure. It is dark olive-gray, firm light silty clay in the upper part and olive-gray, firm silty clay loam in the lower part and has many yellowish-brown mottles. The substratum is olive, stratified, coarse silt and silty clay loam.

Bremer soils have a high content of organic matter. Runoff is slow, and many, small, wet, depressional areas are present. Permeability of the subsoil is moderately slow to very slow. Bremer soils are low in available nitrogen and are medium to high in phosphorus and potassium. They generally are slightly acid, but they range to neutral in reaction.

Representative profile of Bremer silty clay loam on a slope of about 1 percent (368 feet east and 30 feet north of the southwest corner of sec. 20, T. 74 N., R. 37 W.):

Ap—0 to 6 inches, black (N 2/0) silty clay loam; cloddy; friable to firm; neutral; abrupt boundary.

A12—6 to 8 inches, black (N 2/0) silty clay loam; weak, very fine, subangular blocky structure; moisture sheen on peds; firm; neutral; clear boundary.

A13—8 to 14 inches, black (N 2/0) silty clay loam; a few, fine, distinct mottles of very dark gray (5Y 3/1); moderate, very fine, subangular blocky structure; friable to firm; neutral; clear boundary.

AB—14 to 19 inches, black (N 2/0 to 10YR 2/1) light silty clay; many, fine, distinct mottles of olive gray (5Y 4/2) on vertical faces of peds: moderate, fine, subangular blocky structure that grades to weak, fine, prismatic; friable to firm; a few fine pores and some worm casts; neutral; gradual boundary.

B22tg—19 to 28 inches, dark olive-gray (5Y 3/2) light silty clay; a few, fine, prominent mottles of olive (5Y 4/3) and a few, fine, distinct mottles of yellowish brown (10YR 5/6); moderate, fine and medium, subangular blocky structure; firm; distinct sheen on peds, which may be clay; a few very fine pores; neutral; gradual boundary.

B23g—28 to 34 inches, olive-gray (5Y 4/2) heavy silty clay loam; many, fine, prominent mottles of yellowish brown (10YR 5/6) and a few, fine, distinct mottles of dark brown to brown (10YR 4/3); moderate to strong, fine and medium, subangular blocky structure; friable to firm; sheen on peds, which may be clay; a few fine pores; a few oxides; neutral; gradual boundary.

B3g—34 to 42 inches, olive-gray (5Y 5/2) silty clay loam that is olive (5Y 4/3) when kneaded; many, medium, prominent mottles of yellowish brown (10YR 5/6); weak, fine, subangular blocky structure to massive; friable to firm; the number and size of oxides increase with depth; neutral; gradual boundary.

C1—42 to 60 inches, olive (5Y 4/3), stratified coarse silt loam and silty clay loam with yellowish-brown (10YR 5/6) mottles; compaction varies, and the amount of silt and clay also varies; neutral.

The surface layer ranges from black to very dark gray in color and from 12 to 24 inches in thickness. The subsoil is 24 to 36 inches thick and is 38 to 44 percent clay in the finest textured part. It is dark gray to gray in the upper part and olive gray to gray in the lower part. Mottles occur in the subsoil, and they increase in size and abundance with depth. They typically are brown, dark grayish brown, or yellowish brown in color. Stratified coarse silt and silty clay loam occur in places below a depth of 40 inches, and in places sand lenses are present at a depth below 8 feet.

Bremer soils are finer textured than Corley soils and have a thicker surface layer than Humeston soils. They lack the light-colored layer that occurs just below the surface layer in the Corley and Humeston soils.

Bremer silty clay loam (0 to 2 percent slopes) (Br).—This is the only Bremer soil mapped in the county. Individual areas are fairly large, and some are as much as 120 acres.

The profile of this soil is like the one described as representative for the series. The surface layer generally is thickest nearest the uplands. On some of the areas, fresh sediment is deposited each year unless practices for control of runoff and erosion are established on surrounding areas in the uplands.

Included with this soil are some areas of Wabash soils that are too small to be mapped separately.

Most areas of this Bremer soil are in row crops. If artificial drainage is provided and other good management is used, row crops can be grown frequently. A way to protect this soil from local runoff is to construct diversion terraces in areas above this soil. Because this soil dries out slowly, it generally must be worked later in spring than adjacent soils to prevent puddling and clodding. Tilth consequently is likely to be a problem even if drainage is improved. Capability unit IIw-2.

Calco Series

In the Calco series are dark-colored, poorly drained soils on low stream benches. These soils formed in moderately fine textured, calcareous alluvium. The native vegetation was prairie grasses that could tolerate wetness. Calco soils are on bottom lands along the East Nishnabotna River near the town of Griswold. In many places they occupy lower areas than the surrounding Bremer, Colo, Nevin, and Wabash soils and are subject to ponding because of runoff or overflow.

The surface layer is black, friable to firm silty clay loam. It has fine and medium subangular blocky structure and is about 36 inches thick. The subsoil and substratum consist of very dark gray, slightly plastic silty clay loam that is mottled with dark grayish brown and strong brown. Structure is subangular blocky. Calco soils are calcareous throughout the profile. In places fragments of snail shells are in the profile.

These soils have high available moisture capacity and a high content of organic matter. Permeability is moderate to moderately slow. The areas are wet, mainly because the water table is high, but some areas also are subject to overflow and ponding. Calco soils are calcareous throughout. They generally are low or very low in available phosphorus and potassium and medium in available nitrogen.

Representative profile of Calco silty clay loam on a low, alluvial bench (400 feet north and 160 feet east of road from the southwest corner of the SW¼NW¼ sec. 8, T. 74 N., R. 37 W.):

Ap—0 to 9 inches, black (10YR 2/1) silty clay loam; moderate, fine and medium, subangular blocky structure; friable to firm; a few fine pores; fine fragments of snail shells; moderately alkaline; strongly calcareous; gradual boundary.

A12—9 to 16 inches, black (N 2/0) silty clay loam; moderate, fine and medium, subangular blocky structure; friable to firm; a few fine pores; common fine fragments of snail shells; moderately alkaline; strongly calcareous; gradual boundary.

A13—16 to 27 inches, black (N 2/0) silty clay loam; weak, coarse, blocky structure that breaks to moderate, fine, subangular blocky; friable to firm; a few fine pores; a few fine fragments of snail shells; moderately alkaline; strongly calcareous; gradual boundary.

A14—27 to 36 inches, black (N 2/0) silty clay loam; weak, medium, subangular blocky structure; friable to firm; a few fine pores; a few fine fragments of snail shells; moderately alkaline; strongly calcareous; gradual boundary.

Bg—36 to 44 inches, very dark gray (N 3/0) silty clay loam; common, fine, distinct mottles of dark grayish brown (2.5Y 4/2); weak, medium, subangular blocky structure; friable to firm; slightly plastic; moderately alkaline; weakly calcareous; gradual boundary.

Cg—44 to 50 inches, very dark gray (10YR 3/1) light silty clay loam; many, medium, distinct mottles of dark grayish brown (2.5Y 4/2) and common, fine, prominent mottles of strong brown (7.5YR 5/8); massive with some vertical cleavage; friable to firm; slightly plastic; water table present; moderately alkaline; weakly calcareous.

Calco soils typically are black or very dark gray to a depth of 36 inches or more. They grade to lighter gray colors in places below this depth. In many places mottling is masked by the dark colors. The texture generally is silty clay loam throughout the profile. In some places the subsoil is weakly developed, and in other places a thick, dark-colored surface layer directly overlies a gray substratum. Except below the plow layer, boundaries between the soil layers are gradual or diffuse.

Calco soils are calcareous throughout but otherwise are similar to Colo soils.

Calco silty clay loam (0 to 2 percent slopes) (Ca).—This is the only Calco soil mapped in the county. The areas are small. They are scattered on low alluvial benches along the East Nishnabotna River near other soils on benches, such as Bremer, Minden, Nevin, and Wabash silty clay loams.

The profile of this Calco soil is like the one described as representative for the series. This soil is subject to slight ponding in many places. Few suitable outlets are available for surface drainage. Tile drainage is effective if outlets can be provided. Tilth generally is good.

If wetness can be corrected, row crops can be grown frequently on this soil. The soil contains excess lime; special applications of fertilizer containing potassium and phosphorus are needed. Capability unit IIw-1.

Clarinda Series

In the Clarinda series are poorly drained to very poorly drained, dark-colored soils. These soils formed in glacial till. This till is gray clay that commonly is called gumbotil. Gumbotil was the subsoil of a soil that once was at the surface of the nearly level Kansan drift plain. Later a deposit of loess covered the gumbotil, but geologic erosion has removed the loess in many places and has exposed the old, buried soil. These buried or once-buried soils are called paleosols. Since exposure the native vegetation has been prairie grasses.

Clarinda soils commonly occupy narrow areas on side slopes, but many areas are in coves at the heads of drainageways. They have slopes of 5 to 18 percent. These soils are associated with soils derived from both loess and glacial till. They occur in every township in the county but are most common in the eastern two-thirds of the county, east of the East Nishnabotna River, near the Adair, Sharpsburg, and Shelby soils. Areas of Clarinda soils less than 2 acres in size are shown on the soil map by the spot symbol for clay.

The surface layer is black to very dark gray, friable to firm silty clay loam about 12 inches thick. The subsoil, which extends to a depth of 60 inches, is dark grayish-brown to grayish-brown, friable to firm light silty clay in the upper part, and it has many dark-brown to brown mottles. It grades to light brownish-gray, very firm and plastic clay having many yellowish-brown and strong-brown mottles. Structure is subangular blocky.

These soils have high available moisture capacity and medium to low content of organic matter. They are very slowly permeable and are wet and seepy in spring and during periods of high rainfall. Clarinda soils typically are low in available nitrogen, very low to low in available phosphorus, low to medium in available potassium, and medium acid.

Profile of Clarinda silty clay loam on a 7 percent slope that faces north (430 feet west and 50 feet south of the northeast corner of sec. 23, T. 74 N., R. 37 W.):

A1—0 to 7 inches, black (10YR 2/1) silty clay loam: weak, fine, subangular blocky structure; friable; medium acid; clear boundary.

A3—7 to 12 inches, black (10YR 2/1) heavy silty clay loam that is very dark gray (10YR 3/1) when crushed; weak, fine, subangular blocky structure; friable to firm; medium acid; gradual boundary.

IIB1—12 to 16 inches, very dark gray (10YR 3/1) and dark grayish-brown (2.5Y 4/2) light silty clay that is dark gray (10YR 4/1) when crushed; a few, fine, distinct mottles of dark brown to brown (7.5YR 4/4); moderate, fine, subangular blocky structure; friable to firm; medium acid; gradual boundary.

IIB21tg—16 to 22 inches, grayish-brown (2.5Y 5/2) light silty clay; many, medium, distinct mottles of dark brown to brown (7.5YR 4/4) in the lower part of this horizon; a few very dark brown (10YR 2/2) organic stainings; moderate, fine, angular blocky structure; firm; a few, fine, dark oxides; the vertical faces of peds have thick continuous clay films but these are discontinuous on faces of horizontal peds; medium acid; gradual boundary.

IIB22tg—22 to 38 inches, light brownish-gray (2.5Y 6/2) clay; many, medium, distinct mottles of yellowish brown (10YR 5/6); strong, fine, subangular blocky structure; very firm and plastic; common, medium concretions of iron and manganese; thin, discontinuous clay films on vertical and horizontal faces of peds; medium acid; gradual boundary.

IIB31tg—38 to 48 inches, light brownish-gray (2.5Y 6/2) clay; many, coarse, prominent mottles of yellowish brown (10YR 5/8); strong, fine, subangular blocky structure; very firm and plastic; many, medium and coarse concretions of iron and manganese; faint, thin clay films on vertical cleavage faces; medium acid; gradual boundary.

IIB32tg—48 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay or clay; many, coarse, prominent mottles of strong brown (7.5YR 5/6); strong, fine, subangular blocky structure; very firm and plastic; iron oxides are concentrated in pockets and occur as concretions; medium acid.

The surface layer ranges from black to very dark gray and very dark grayish brown to dark gray, depending upon how much erosion has taken place. It commonly is 10 to 14 inches thick in relatively uneroded areas. The subsoil ranges from dark gray to light brownish gray and light olive gray. Mottles of dark grayish brown, yellowish brown, and very dark gray are common in the subsoil and increase in size and number with depth. Thickness of the subsoil varies, but in most places it ranges from 2½ to 5 feet. The texture throughout the subsoil is silty clay or clay, and the clay content ranges from 45 to 55 percent. In most of the subsoil, pebbles and fine gravel generally are lacking.

Clarinda soils are grayer than Adair soils and have a thicker, more clayey subsoil. They also have less sand and gravel in the surface layer and subsoil.

Clarinda silty clay loam, 5 to 9 percent slopes (CdC).—In many places this soil is in coves at the heads of drainageways on slopes below soils formed in loess. In other places this soil occupies narrow areas on side slopes above areas of Adair and Shelby soils. Individual areas are seldom more than 15 acres in size.

The surface layer is black to very dark gray and generally is 7 to 14 inches thick. Its content of organic matter is higher than that in any of the other Clarinda soils. The old, buried subsoil generally is thicker than in Clarinda soils on stronger slopes. In seasons of high rainfall and after the frost leaves the ground in spring, this soil is wet and seepy. As it dries it becomes hard and cloddy, and in dry summers deep cracks form in it. This soil erodes readily when cultivated, has low fertility, is in poor tilth, and is difficult to manage.

Included with this soil are some areas of a Clarinda silty clay loam on slopes of 2 to 5 percent. These included areas are upslope from this soil.

Areas of this Clarinda soil generally are small and are farmed the same as surrounding soils better suited to row crops. This soil is well suited to hay or pasture, though row crops can be grown occasionally if wetness and erosion are controlled. Some areas are suitable for wildlife habitats.

Wetness and seepage can be reduced by placing interceptor tile upslope in the more permeable soils on loess. A way to control erosion and prevent gullying is to construct terraces upslope to reduce the amount of runoff water moving over this soil. Tilth and fertility can be improved, and the productivity of grain and forage crops increased, if crop residues and fertilizer are added. Capability unit IVw-1.

Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded (CdC2).—This soil generally occupies narrow areas on side slopes or is in coves at the heads of drainageways. The areas are downslope from the Ladoga, Marshall, and Sharpsburg soils and upslope from drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. Individual areas generally are between 5 and 20 acres in size.

The subsoil of this soil generally is thicker than that in the Clarinda soils on steeper slopes. In many places plowing has mixed material from the subsoil into the surface layer. The soil therefore usually is difficult to till. The surface soil is hard and cloddy when dry. Cracks form in the surface layer as it dries and extend into the subsoil. Most areas are seepy and wet, especially in spring and in rainy seasons.

Included with this soil are small areas that have less than 3 inches of the original surface soil remaining. In these areas the gray clay subsoil is exposed in many places. Also included are some small areas of Adair and Shelby soils.

Many areas of this Clarinda soil are in permanent pasture, which generally is a good use. Most cultivated areas are farmed along with adjoining, more productive soils. If wetness is reduced and erosion is controlled, row crops can be grown occasionally.

Placing interceptor tile in soils upslope is a way to reduce wetness. Erosion can be controlled by terracing the soils upslope. Tile does not function in this soil, and the clayey subsoil, irregular slopes, and gullies make construction of terraces impractical. In many places corn grown on this soil is stunted and yellowed. Capability unit IVw-1.

Clarinda silty clay loam, 9 to 14 percent slopes (CdD).—This soil occupies many narrow areas around side slopes and in concave coves at the heads of upland drainageways. The areas are between the higher lying Ladoga, Marshall, and Sharpsburg soils and the lower lying Adair and Shelby soils. They generally are between 5 and 15 acres in size and occur throughout the county.

The surface layer is black to very dark gray in color and ranges from 7 to 14 inches in thickness. Permeability of the subsoil is very slow, and runoff therefore is excessive. The content of organic matter is about medium. This soil is wet and seepy in spring and in seasons when rainfall is above average. It is sticky when wet and is hard and cloddy when dry. The soil consequently is difficult to till and hard to manage.

Included with this soil are small areas of Adair and Shelby soils. Also included are some areas of a soil that has slopes of as much as 19 percent.

This Clarinda soil is poorly suited to cultivated crops, but some areas are cropped along with surrounding soils more suitable for cultivation. Row crops are grown occasionally when renovating pastures and establishing stands of hay.

Terracing the loessal soils upslope and farming them on the contour are ways of controlling erosion. Placing interceptor tile upslope in the Ladoga, Marshall, and Sharpsburg soils helps to reduce wetness. Capability unit IVe-2.

Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded (CdD2).—In some places this soil occupies narrow areas around the sides of hills, but in many other places the areas are around the heads of upland drainageways. The areas are between the higher lying Marshall and Sharpsburg soils and the lower lying Adair and Shelby soils. They range from about 5 to 25 acres in size and are scattered throughout the county.

This is the most extensive Clarinda soil mapped in the county, and its profile is like the one described as representative for the series. Material from the subsoil has been mixed in the surface layer by plowing, and this layer is sticky and plastic when wet and is hard when dry. Tilth is poor. Permeability is very poor, and the soil dries out slowly. Many areas are very seepy and wet.

Included with this soil are some areas of Adair and Shelby soils. These included soils are too small to be mapped separately.

This Clarinda soil is poorly suited to cultivated crops, though some areas are cropped along with surrounding soils more suitable for cultivation. Crops on this soil generally are yellow and stunted in growth. This soil is well suited to hay or pasture, and many areas are left in permanent pasture. Some isolated areas are suitable for use as wildlife habitats.

Because of low fertility, it is hard to establish a good cover of vegetation on this soil. Large amounts of barnyard manure and fertilizer are therefore needed when establishing grasses and legumes for hay or pasture. Wet, seepy areas can be partly dried by placing interceptor tile upslope in the Ladoga, Marshall, and Sharpsburg soils. Even then, this soil generally is somewhat wet and is hard to manage. Gullies in this soil need to be filled in, shaped, and seeded to grass for use as waterways. Farming on the contour and placing terraces just above this soil in soils better suited to terracing provide protection from further erosion and gullying. Capability unit IVe-2.

Clarinda soils, 5 to 18 percent slopes, severely eroded (CeD3).—These undifferentiated soils occupy narrow areas on side slopes and in coves at the heads of drainageways. They are between the higher lying Ladoga, Marshall, and Sharpsburg soils and the lower lying Adair and Shelby soils. Clarinda soils are in the eastern two-thirds of the county. Individual areas generally are between 5 and 15 acres in size.

The surface layer of these soils is 3 inches or less thick. It is dark grayish brown or dark gray in color and is silty clay loam, silty clay, or clay in texture. Most of the original surface layer has been lost through erosion, and in many places the subsoil has been exposed by plowing. The present surface layer is clayey and is in poor tilth. These soils puddle readily and are slow to absorb moisture. When dry, the surface layer becomes hard and cloddy and cracks readily. Consequently, tillage is difficult. Permeability of the subsoil is very slow, and runoff therefore is excessive. Even if seepage is controlled by interceptor tile, the soils are very slow to dry out and remain wet for long periods.

Included with these soils are many areas of Adair and Shelby soils that are too small to be mapped separately. Also included are small areas of soils that are not eroded or that are moderately eroded. In other included areas a thin layer of loess is on the surface at the upper edge of the soil areas.

These Clarinda soils are not suitable for row crops, but small areas generally are farmed with surrounding soils that normally are used for cultivated crops. Pasture is a good use. Some areas are suitable for use as wildlife habitats. Many of the side slopes are cut by gullies, and some areas are left idle because of severe gullying.

Constructing terraces above these soils in the Ladoga, Marshall, and Sharpsburg soils helps to control further erosion and gullying. Applying barnyard manure and adding fertilizer are ways to improve soil tilth and fertility. These practices also are helpful in establishing seedings of hay and pasture. Capability unit VIe–2.

Colo Series

Colo soils are nearly level, dark colored, and poorly drained. These soils formed in silty alluvium. The native vegetation was prairie grasses that could tolerate wetness. Colo soils occur throughout the county. They occupy many areas along the East Nishnabotna River on low stream benches or second bottoms. In most places they are associated with the Kennebec, Nodaway, and Zook soils on first bottoms and with the Judson soils in narrow upland drainageways.

The surface layer is black, friable silty clay loam that has medium and fine subangular blocky structure and is about 30 inches thick. The subsoil is black or very dark gray, friable to firm silty clay loam and extends to a depth of about 50 inches or more. It has weak prismatic structure that breaks to subangular blocky.

These soils have high available moisture capacity and high content of organic matter. Permeability of the subsoil is moderate to moderately slow. The soils generally are wet because the water table is high and the areas are subject to flooding. Surface drainage is desirable in many places, but tile drains work quite well in these soils. Tilth generally is good in cultivated areas. Colo soils are medium in available nitrogen and phosphorus, are medium to high in potassium, and are slightly acid to neutral.

Representative profile of Colo silty clay loam on a slope of about 1 percent (84 feet east and 354 feet south of the northwest corner of sec. 33, T. 75 N., R. 36 W.):

Ap—0 to 8 inches, black (10YR 2/1) or very dark brown (10YR 2/2) light silty clay loam; weak, medium, subangular blocky structure; friable; a few fine roots; seems compacted; medium acid; clear boundary.

A12—8 to 18 inches, black (N2/0) silty clay loam that is black (10YR 2/1) when crushed; weak and moderate, fine, subangular blocky structure; friable; a few fine wormholes; slightly acid; gradual boundary.

A13—18 to 30 inches, black (N2/0) silty clay loam; weak, medium, prismatic structure that breaks to weak and moderate, fine, subangular blocky structure; friable; a few fine pores; neutral; gradual boundary.

B1—30 to 43 inches, black (10YR 2/1) silty clay loam that is black (10YR 2/1) or very dark gray (10YR 3/1) when crushed; weak, medium, prismatic structure that breaks to weak and moderate, medium, subangular blocky; friable to firm; slight sheen on peds; a few fine wormholes; neutral; gradual boundary.

B2—43 to 51 inches, very dark gray (10YR 3/1) heavy silty clay loam; weak, medium, prismatic structure that breaks to moderate, medium, subangular blocky; firm; slight sheen on peds; neutral.

Colo soils have a thick, black to very dark gray surface layer and a weakly developed subsoil. The subsoil in many areas is darkened with organic matter. The black to very dark gray colors generally extend to a depth of 36 inches or more, and in places gray or dark-gray colors are present below this depth. Any mottles that are present generally are masked by the dark colors. In texture the surface layer and subsoil are silty clay loam. Some areas of Colo soils, however, have 6 to 16 inches of overwash on the surface. This overwash is very dark grayish-brown, stratified silt loam. Except below the plow layer, boundaries between the soil layers are gradual or diffuse.

Colo soils, unlike Zook silty clay loam, are silty clay loam throughout, rather than silty clay at a depth below 20 inches. They are more clayey than the Kennebec soils, have stronger structure, and are more poorly drained.

284-563 O—68——2

Colo silty clay loam (0 to 2 percent slopes) (Cg).—This soil commonly occurs in both narrow and wide stream valleys throughout the county. In many places the areas are at the place where small tributaries empty onto bottoms of the main stream. Many small areas are in depressions, and water is likely to stand in these areas after rains. A few small areas are severely channeled. Some areas are as much as 100 acres in size.

This is the most extensive Colo soil in the county. Its profile is like the one described as representative for the series.

Included with this soil are some areas of Kennebec, Nodaway, and Wabash soils less than 2 acres in size. These areas are too small to be mapped separately. Also included are some areas that have a surface layer of black silt loam about 20 to 30 inches thick.

Most of this Colo soil is used for cultivated crops, even though the areas are flooded occasionally. Areas that are flooded frequently or that are inaccessible are in pasture. A few severely channeled areas, which total about 25 acres, also are in pasture.

Row crops can be grown frequently on this soil. In many places tile drainage is needed to reduce wetness. In areas that are frequently flooded, surface drainage may also be needed. Outlets for both tile and surface drainage generally are available. If adequate drainage is provided and flooding is controlled, this soil is highly productive. Some areas can be protected from runoff by placing diversion terraces at the base of adjacent slopes. Capability unit IIw–1.

Colo silt loam, overwash (0 to 2 percent slopes) (Ch).—Some areas of this soil are at the base of upland slopes near Judson soils. Other areas are on the larger flood plains, nearer the stream channels, and are associated with Colo silty clay loam and with Kennebec, Nodaway, and Wabash soils. Individual areas generally are between 10 and 60 acres.

This soil has 6 to 16 inches of stratified, very dark grayish-brown, silty overwash on the surface, but it otherwise is similar to Colo silty clay loam. The overwash generally is silt loam in texture. It was deposited by overflow from adjacent rivers or creeks in most places, but in some places it was laid down by streams flowing through the uplands. In some areas the overwash is silty clay loam in texture and is mottled with iron stains. Because the material has been deposited so recently, the content of organic matter in this soil is medium to low. The subsoil is poorly drained, but the overwash is somewhat better drained.

Included with this soil are some areas of Colo silty clay loam that are too small to be mapped separately.

If adequate drainage is provided and if this Colo soil is protected from overflow, row crops can be grown frequently. Tile drains work satisfactorily and are needed in many areas. In areas not protected from overflow, the response of crops is reduced in some years because of flooding. Capability unit IIw–1.

Colo-Nodaway complex (0 to 2 percent slopes) (Cn).—The soils of this complex are on first bottoms adjacent to stream channels. They are mostly in the southern part of the county next to the higher lying Adair, Ladoga, Shelby, and Sharpsburg soils. In many places, however, Judson soils also border areas of this complex. Individual areas generally range from 10 to 80 acres.

Colo silty clay loam and Nodaway silt loam are the dominant soils in this complex, and each is described in detail under its respective series.

These soils are subject to flooding by meandering streams or by runoff from higher lying areas. The Colo soil generally is wet because of a high water table and flooding. Internal drainage in the Nodaway soil is fair, but the areas sometimes are wet because of overflow. The Nodaway soil is easier to work than the Colo soil.

Included with this complex are some areas that have 6 to 16 inches of recent overwash on the surface. These areas are too small to be mapped separately. Also included are small areas of Zook soils.

If drainage is provided and flooding is controlled, row crops can be grown frequently on soils of this complex. Surface drainage or tile drainage is needed in many places. In many places diversion terraces can be placed at the base of adjacent uplands to control runoff. Capability unit IIw-1.

Corley Series

The Corley series consists of nearly level, dark-colored soils that are poorly drained. These soils formed in deep deposits of loess on low benches. The native vegetation was prairie grasses that could tolerate wetness. Corley soils occupy shallow depressions in association with the Marshall and Minden soils.

The surface layer is black or very dark brown, friable silt loam that has fine granular structure and is about 12 inches thick. It overlies a layer that generally is dark gray in the upper part and grayish brown in the lower part. This layer is friable silt loam that has weak platy or fine subangular blocky structure and is about 12 inches thick. The subsoil extends to a depth of about 48 inches and is grayish-brown, firm silty clay loam that has many, strong-brown mottles and subangular blocky structure. The substratum is massive, grayish-brown silt loam that has many strong-brown mottles.

These soils are easy to till if they are not worked when wet. Permeability of the subsoil is moderately slow, and tiling is practical if the distance to an outlet is not too great. Because these soils are in depressions, water ponds on the areas after rains. Surface drains are best to use for draining the areas if outlets are available. Corley soils are high in organic matter and in available moisture capacity. They are low in available nitrogen, medium in phosphorus, and medium to high in potassium. They are mostly medium acid but range to strongly acid. Areas less than 1 acre in size are shown on the detailed soil map by a spot symbol.

Representative profile of Corley silt loam in a shallow depressional area (580 feet west and 1,240 feet south of the northeast corner of sec. 31, T. 75 N., R. 37 W.) :

Ap—0 to 6 inches, black (10YR 2/1) or very dark brown (10YR 2/2) silt loam that is very dark brown (10YR 2/2) when crushed; weak, very fine, subangular blocky structure that breaks to weak, fine, granular structure; friable; a few very fine pores; a few very fine silica coatings; seems slightly compacted; medium acid; clear boundary.

A12—6 to 13 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) when dry; weak, thin, platy structure that breaks to moderate, fine, granular; very friable; many fine pores; a few gray to light-gray (10YR 6/1, dry) silt coatings; a few soft concretions; medium acid; gradual boundary.

A21—13 to 18 inches, very dark gray (10YR 3/1) and dark gray (10YR 4/1) silt loam that is very dark gray (10YR 3/1) when crushed; weak, thin, platy structure that breaks to moderate, very fine, subangular blocky; friable; many fine pores; a few gray to light-gray (10YR 6/1, dry) silt coatings; medium acid; clear boundary.

A22—18 to 24 inches, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) silt loam that is grayish brown (10YR 5/2) when crushed; weak, medium, platy structure that breaks to moderate, fine subangular blocky; friable; a few medium pores; abundant, light-gray (10YR 7/1, dry) silt coatings; many soft concretions; strongly acid; gradual boundary.

ABg—24 to 31 inches, dark-gray (10YR 4/1) and grayish-brown (10YR 5/2) silt loam that is grayish brown (10YR 5/2) when crushed and light gray (10YR 8/1) when dry; many, fine, distinct mottles of strong brown (7.5YR 5/8) ; moderate, fine, subangular blocky structure; friable; thin, discontinuous clay films; many, light-gray (10YR 7/1, dry) silt coatings; many fine pores; many, fine, soft concretions; strongly acid; clear boundary.

B2tg—31 to 37 inches, grayish-brown (2.5Y 5/2) silty clay loam; many, medium, distinct mottles of dark gray (10YR 4/1) and many, medium, prominent mottles of strong brown (7.5YR 5/8) ; moderate, medium, subangular blocky structure; friable to firm; thin, discontinuous clay films; a few fine pores; a few gray to light-gray (10YR 6/1, dry) silt coatings; medium acid; gradual boundary.

B3g—37 to 46 inches, grayish-brown (2.5Y 5/2) light silty clay loam; many, medium, prominent mottles of strong brown (7.5YR 5/8) ; weak, medium, subangular blocky structure to massive; friable to firm; a few discontinuous clay films and many, fine, distinct clay fillings of dark gray (10YR 4/1) ; medium acid; gradual boundary.

C1g—46 to 60 inches, grayish-brown (2.5Y 5/2) silt loam that is brown (10YR 5/3) when crushed; many, medium, prominent mottles of strong brown (7.5YR 5/8) and a few, fine, distinct mottles of dark gray (10YR 4/1) ; massive; slightly acid.

The surface layer is 10 to 16 inches thick and is black or very dark brown in color. Just below is a layer that generally is dark gray to grayish brown, has weak platy or fine subangular blocky structure, and is 12 to 24 inches thick. The subsoil typically is dark grayish brown or grayish brown with dark yellowish-brown, strong-brown, dark-brown, or grayish mottles. It is 20 to 30 inches thick. The uppermost layers in the profile typically are silt loam in texture. The subsoil is silty clay loam and has a clay content of about 30 to 34 percent. The underlying material is grayish-brown to olive-gray silt loam with strong-brown and yellowish-brown mottles.

Corley soils are not so fine textured as Humeston soils and depth to the zone of maximum clay content is more variable than in those soils. They are similar to the Minden and Marshall soils, but those soils lack the light-colored subsurface layer typical of Corley soils.

Corley silt loam, 0 to 2 percent slopes (CoA).—This is the only Corley soil mapped in the county. It is in shallow depressions that are between 3 and 5 acres in size. Its profile is like the one described as representative for the series.

The surface layer of this soil is quite variable in thickness. In places material washed from the slightly higher lying Marshall and Minden soils has been deposited on the areas.

This soil is farmed along with the surrounding Marshall and Minden soils. Row crops can be grown frequently if adequate drainage is provided. Tile drains and surface drains can be used if outlets are available. Even though drainage is provided, the response of crops generally is poorer than on the Marshall and Minden soils. Capability unit IIw–2.

Gara Series

The soils of the Gara series are moderately dark colored and moderately well drained. These soils formed from Kansan and Nebraskan till in the uplands under prairie grasses and trees. The trees were chiefly elm and oak but included some hickory.

Gara soils are in topographic positions that range from the strongly sloping lower parts of slopes to steep, irregular, convex parts of side slopes. Slopes range from 9 to 25 percent. The Gara soils are in most townships of the county. Many of the areas are on slopes adjacent to the bottom lands along major streams. These soils are associated with the Ladoga soils, which are upslope; with Judson-Colo complex, 2 to 5 percent slopes, which is downslope in drainageways; and with soils in the Shelby-Adair complexes.

The surface layer is very dark gray friable loam that has fine granular structure and is about 6 inches thick. Just below is dark grayish-brown, friable silt loam that has very weak platy structure and is about 4 inches thick. The subsoil extends to a depth of about 36 inches. It is dark brown to brown in the upper part and grades to yellowish brown with a few olive-gray mottles. It is firm clay loam and has subangular blocky structure. The substratum is massive, yellowish-brown, firm clay loam with common, light olive-gray mottles and a few streaks of calcium carbonate.

These soils are subject to erosion and are gullied in some places. They have high available moisture capacity and low content of organic matter. Permeability is moderately slow. Gara soils are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

Representative profile of Gara loam on a 15 percent slope facing east (50 feet east of the center of the road in the SW¼SW¼NW¼ sec. 33, T. 75 N., R. 36 W.):

A1—0 to 6 inches, very dark gray (10YR 3/1) loam; moderate, fine, granular structure; friable; medium acid; gradual boundary.

A2—6 to 10 inches, dark grayish-brown (10YR 4/2) silt loam that is mixed somewhat with very dark gray (10YR 3/1) and dark brown to brown (10YR 4/3) and is dark grayish brown (10YR 4/2) when kneaded; very weak, very thick, platy structure that breaks to weak, very fine, subangular blocky; very friable; many, gray to light-gray (10YR 6/1, dry) grainy coats; medium acid; clear boundary.

B1—10 to 15 inches, dark-brown to brown (10YR 4/3) clay loam; moderate, fine, subangular blocky structure; friable to firm; common, gray to light-gray (10YR 6/1, dry) grainy coats and some very dark gray (10YR 3/1) coats; a few small pebbles; strongly acid; clear boundary.

B21t—15 to 19 inches of clay loam, the peds of which have dark-brown to brown (10YR 4/3) exteriors and yellowish-brown (10YR 5/4) interiors, and that is yellowish brown (10YR 5/4) when kneaded; common very dark gray (10YR 3/1) coats; moderate, fine, subangular blocky structure; firm; thin, discontinuous clay films on horizontal faces of peds; many small pebbles; strongly acid; clear boundary.

B22t—19 to 28 inches of clay loam, the peds of which have yellowish-brown (10YR 5/4) exteriors and yellowish-brown (10YR 5/6) interiors, and that is yellowish brown (10YR 5/6) when kneaded; strong, medium, subangular blocky structure; firm; thick, continuous clay films on horizontal and vertical faces of peds; fine, soft concretions of iron and manganese; many small pebbles; strongly acid; clear boundary.

B3—28 to 37 inches, yellowish-brown (10YR 5/6) clay loam; a few, medium, distinct mottles of light olive gray (5Y 6/2); strong, medium, subangular blocky structure; firm; thin, discontinuous clay films on horizontal and vertical faces of peds; a few, fine, soft concretions of iron and manganese; a few small pebbles; medium acid; gradual boundary.

C—37 to 45 inches, yellowish-brown (10YR 5/4) clay loam; common, fine, distinct mottles of light olive gray (5Y 6/2); massive; firm; common, fine concretions of iron and manganese; a few pebbles of small and medium size; noncalcareous; some streaks of calcium carbonate.

In areas that are not eroded, the surface layer is black to very dark gray and is 4 to 10 inches thick. Just below is a grayish layer that is 2 to 5 inches thick. This subsurface layer is lacking in eroded areas or in cultivated fields, where it is mixed into the plow layer. Distinct coatings of silt are on the exterior of peds in the lower part of the surface layer and in the subsoil if the subsurface layer is lacking.

The subsoil generally is dark-brown to yellowish-brown medium to heavy clay loam that is 16 to 32 inches thick. Thin films of clay are on the exterior of peds in the subsoil, and olive-gray and yellowish-brown mottles are common. Pebbles and stones occur throughout the profile. The substratum is mottled yellowish brown to light olive gray and is calcareous at a depth below 36 inches.

Gara soils have a thinner surface layer than Shelby soils, are more acid in the most acid part, and unlike those soils, have a light-colored layer just below the surface layer. They are less clayey than Adair soils. Also, unlike those soils, Gara soils have a light-colored layer just below the surface layer but lack reddish colors in the subsoil.

Gara loam, 9 to 14 percent slopes (GaD).—This soil is on side slopes just below less sloping Ladoga soils. In many places it occupies the entire lower part of the side slope and extends downslope to narrow upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes.

In most places this soil has a surface layer of very dark gray, friable loam that is 4 to 8 inches thick. Just below is a light-colored layer. Some areas are cultivated. Here the subsurface layer has been mixed with the surface layer by plowing, and the present surface layer is very dark grayish-brown loam. This soil is low in content of organic matter, absorbs moisture slowly, and is subject to sheet and gully erosion.

Included with this soil is a small acreage of Gara soils on slopes of 5 to 9 percent that have a very dark grayish-brown plow layer. Also included are narrow, seepy areas of Adair soils and small areas of Ladoga soils derived from loess. All of these included soils are too small to be mapped separately.

This Gara soil should be kept in hay or pasture most of the time. A row crop can be grown occasionally. This soil generally is cropped the same as surrounding soils that are better suited to row crops. Many of the areas remain under a cover of grasses and trees and are used for pasture.

If this soil is used for row crops, terracing and cultivating on the contour are needed. The irregular slopes and gullies, however, make it difficult to lay out and install terraces in some places. Terracing the more permeable

Ladoga soils upslope is a way to help reduce erosion and gullying.

The carrying capacity of most pastures can be increased by removing the trees and brush and then preparing a seedbed in the sod and seeding better yielding grasses and legumes. Forage crops respond if lime and phosphate are applied. These practices also help to establish new seedings in areas used for pasture or hay. Capability unit IVe–1.

Gara loam, 9 to 14 percent slopes, moderately eroded (GaD2).—This soil is on side slopes just below less sloping Ladoga soils and upslope from Judson-Colo complex, 2 to 5 percent slopes, in drainageways. In many places the areas extend down long narrow ridges dissected by many gullies. Individual areas are fairly large, and some are as much as 50 or 60 acres in size.

The surface layer of this soil is very dark grayish-brown loam. In cultivated areas material from the subsurface layer and subsoil has been mixed with the surface layer by plowing. This soil absorbs moisture slowly and generally is in poor tilth. Sheet and gully erosion are common.

Included with this soil are some areas of a soil that has a surface layer of very dark grayish-brown, firm clay loam less than 3 inches thick. These areas are shown on the map by the spot symbol for severe sheet erosion. Also included are some narrow, seepy areas of Adair soils and some areas of Ladoga soils derived from loess that are less than 3 acres in size. The seepy areas are near the upper part of areas of this Gara soil. All of these included soils are too small to be mapped separately.

This Gara soil should be kept in hay or pasture most of the time, though a row crop can be grown occasionally. Most areas are in pasture, and on many of the areas brush or trees grow in places. A few areas are cropped.

The carrying capacity of the pastures can be increased by clearing the trees and brush from the areas and establishing grasses and legumes. The grasses and legumes respond well if lime and fertilizer are applied. Wetness caused by seepage can be reduced by placing interceptor tile in areas upslope from this soil. Capability unit IVe–1.

Gara loam, 14 to 18 percent slopes (GaE).—This soil is downslope from less sloping Ladoga soils and from less sloping Gara soils. In many places it occupies the entire lower part of a side slope, just above narrow upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. Individual areas range from 10 to 30 acres in size.

The surface layer of this soil is very dark gray loam 4 to 8 inches thick. The subsurface layer is dark grayish-brown silt loam and is more distinct than in moderately eroded Gara soils.

Included with this soil are a few narrow, wet, seepy areas of Adair soils. Also included are some areas of Ladoga soils derived from loess. All of these included areas are too small to be mapped separately.

This Gara soil is not suited to cultivated crops. Most areas have a cover of scattered trees and grasses and are used for pasture. The areas are also suitable for wildlife habitats.

The carrying capacity of many pastured areas can be improved by clearing them and establishing pasture plants that are more productive. New pasture seedings respond well if lime and fertilizer are applied. Under good management, productivity of the pastures generally is good. Capability unit VIe–1.

Gara loam, 14 to 18 percent slopes, moderately eroded (GaE2).—This soil is between Ladoga soils on ridgetops or the upper part of side slopes and Judson-Colo complex, 2 to 5 percent slopes, in narrow upland drainageways. In many places the areas are narrow and are on strongly sloping, convex side slopes. Most of the acreage is along the lower slopes of the uplands that border bottom lands of the major streams and their tributaries. Individual areas are fairly large, and some are as much as 80 to 100 acres.

This is the most extensive Gara soil in the county, and its profile is like the one described as representative for the series. The soil is low in content of organic matter, absorbs moisture slowly, and is subject to further erosion. In many places the surface is stony. Also, tilth is poor in many places. In seasons when rainfall is high, the upper part of the soil areas are seepy and wet. In cultivated areas clay loam formerly in the subsoil has been mixed with the remaining original surface layer by plowing.

Included with this soil are narrow areas of Adair soils, which are at the upper edges of this soil, and some areas of Ladoga soils. These included soils are too small to be mapped separately.

This Gara soil is not suited to row crops but is well suited to pasture. Wildlife habitats are a good use for some areas. Many small areas are farmed the same as surrounding soils better suited to crops. Most areas, however, are in permanent pasture. These areas generally have trees or brush growing on them.

Contour farming and terracing the more permeable soils upslope are ways to keep sidehill gullies from forming and to prevent further losses of soil. Many pastured areas need to be cleared of trees and brush. Then suitable mixtures of grasses and legumes should be seeded. In some areas gullies make the use of farm machinery in renovating pastures difficult. Applying lime and fertilizer helps to improve pastures and assure the success of renovation programs. Capability unit VIe–1.

Gara loam, 18 to 25 percent slopes, moderately eroded (GaF2).—This soil is upslope from Ladoga soils and downslope from Judson-Colo complex, 2 to 5 percent slopes, which is in narrow upland drainageways. The slopes generally are long and convex. Individual areas are mostly less than 30 acres in size.

The surface layer generally is very dark grayish brown and ranges from loam to clay loam in texture. In most places all of the lighter colored subsurface layer and part of the subsoil are mixed with the surface layer, which is 4 to 6 inches thick. This soil is shallower to calcareous material than less sloping Gara soils. Depth to calcareous material is between 36 and 48 inches in many places.

Included with this soil are some areas of a soil that is not eroded and that has a surface layer of very dark gray loam about 8 inches thick. Also included is a small acreage of a severely eroded soil that has a surface layer of dark grayish-brown or dark-brown loam to clay loam and some areas of Ladoga soils. All of these included soils are too small to be mapped separately.

Most areas of this Gara soil have a cover of various kinds of trees and grasses. Because of the steep slopes, rapid runoff, and hazard of further erosion the soil is not suited to cultivated crops. Pastures on this soil are only moderately productive, and renovating pastures is impractical because of the trees, many gullies, and steep slopes. The areas are suitable for use as wildlife habitats. Capability unit VIIe-1.

Gara soils, 14 to 18 percent slopes, severely eroded (GrE3).—These soils are on moderately steep, short side slopes just below less sloping Ladoga soils. They are upslope from less eroded Gara soils and from Judson-Colo complex, 2 to 5 percent slopes, in upland drainageways. Individual areas are scattered along the major streams in the county and are as much as 20 acres in size.

Most of the original surface layer of these soils has been washed away. The present surface layer is dark grayish-brown clay loam 3 inches or less thick. In places dark-brown material formerly in the subsoil is on the surface. These soils generally are shallower to calcareous material than most of the other Gara soils. In many places depth to calcareous material is between 36 and 48 inches.

Permeability of these soils is moderately slow. Runoff is rapid. Cultivation and overgrazing have caused severe erosion damage, and some areas are cut by deep gullies. The gullies need to be shaped and reseeded to grasses.

These soils are suited to pasture, but grazing must be limited. Renovating the pastures, where practical, increases their productivity. These soils also are suitable for wildlife habitats. Capability unit VIIe-1.

Hagener Series

Hagener soils are excessively drained. These soils formed under prairie grasses in sand blown by wind onto the uplands from nearby stream valleys. They are dominantly along the east side of the East Nodaway River and along Troublesome and Turkey Creeks. These soils generally are on slopes that face west and south. They typically are below the ridgetops in narrow areas along side slopes, or they occupy small areas at the end of rounded slopes. In many places Marshall soils surround the areas. A few small areas of Hagener soils occur within areas of Sharpsburg soils.

The surface layer is very dark brown, friable fine sandy loam that has very fine and fine granular structure and is about 8 inches thick. It overlies dark-brown to brown and very dark brown, friable loamy fine sand that is 8 inches thick. This transitional layer is lacking in many areas. The subsoil is dark-brown to brown or dark yellowish-brown, very friable to loose loamy fine sand that is about 12 inches thick. The substratum, a yellowish-brown, loose fine sand, has common, olive-gray mottles and a few, thin, discontinuous, darker colored bands in the lower part.

These soils are droughty. They have very low available moisture capacity and low content of organic matter. Permeability is very rapid. Available nitrogen, phosphorus, and potassium are very low to low. Hagener soils are medium acid.

Representative profile of Hagener fine sandy loam that is moderately eroded and is on a slightly convex slope of 11 percent that faces north (400 feet south and 70 feet west of the northeast corner of NW¼NW¼ sec. 6, T. 76 N., R. 35 W.):

Ap—0 to 7 inches, very dark brown (10YR 2/2) fine sandy loam with splotches of dark brown to brown (10YR 4/3); weak, very fine and fine, granular structure; friable; horizon appears to consist of loess and loamy sand; medium acid; clear boundary.

AB—7 to 15 inches, dark-brown to brown (10YR 4/3) and very dark brown (10YR 2/2) loamy fine sand; weak, fine, granular and very weak, fine, subangular blocky structure; very friable; some material from the surface horizon is mixed with this horizon; medium acid; gradual boundary.

B2—15 to 25 inches, dark-brown to brown (10YR 4/3) or dark yellowish-brown (10YR 4/4) loamy fine sand; very friable to loose; medium acid; gradual boundary.

C—25 to 60 inches, yellowish-brown (10YR 5/4) fine sand; common, medium, distinct mottles of olive gray (5Y 5/2) in the lower part of this horizon; single grain; loose; a few, thin, discontinuous bands of darker colored loamy fine sand ⅛ to ¼ inch thick are common at a depth between about 40 and 60 inches; medium acid.

The surface layer is very dark brown to dark grayish brown and ranges from 8 to 16 inches in thickness, unless eroded. Its texture ranges from fine sandy loam to loamy fine sand. The subsoil is dark-brown to brown or dark yellowish-brown loamy fine sand. Just below is the substratum of yellowish-brown to brown fine sand. In most places thin bands of loamy fine sand that contain some iron accumulation occur in the substratum.

Hagener soils are coarser textured than Ankeny soils, but those soils are dark colored to a greater depth.

Hagener soils, 9 to 18 percent slopes, moderately eroded (HaD2).—These undifferentiated soils are downslope from Marshall soils and generally occupy narrow areas around sidehills. The areas extend downslope to Marshall soils and to upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. Individual areas generally are between 5 and 15 acres in size.

The profile of these soils is like the one described as representative for the series. Texture of the surface layer varies somewhat because in places material from surrounding soils on loess has been mixed into the surface layer by plowing. Both sandy loam and loamy sand occur, but the areas are too intermingled to be mapped separately. In about 60 acres the texture is silty clay loam that is 20 to 30 inches thick over sand.

Included with these soils are some areas that have a surface layer that is 7 to 12 inches thick and some severely eroded areas that have a surface layer less than 3 inches thick. The severely eroded areas are shown on the detailed soil map by the symbol for severe sheet erosion. Also included are some areas that have slopes of 5 to 9 percent. All of these included soils are too small to be mapped separately.

These Hagener soils are not suited to row crops, because of the hazards of further wind and water erosion. Some areas are cropped because the surrounding soils on loess are better suited to row crops. These soils are good for hay or pasture, and much of the acreage is pastured.

In areas that are cultivated, all crop residues ought to be left on the surface. This practice helps to control soil blowing and reduces runoff. Terracing the soils upslope and farming them on the contour are ways to control water erosion. A cover of vegetation can be established and the response of crops improved if manure is added and if fertilizer is applied. Capability unit VIs-1.

Humeston Series

In the Humeston series are nearly level, dark-colored soils that are poorly drained to very poorly drained. These soils formed in alluvium under prairie grasses that could tolerate wetness. They are on low benches, mostly on bottom lands of the East Nishnabotna River and its tributaries. Humeston soils are associated with the Bremer, Colo, Nevin, and Zook soils. They generally are in depressional areas and are much wetter than surrounding soils. The areas are likely to be ponded because of overflow from nearby streams. Some areas receive runoff from surrounding soils.

The surface layer is black, friable to firm heavy silt loam that has fine subangular blocky and granular structure and is about 12 inches thick. It overlies dark-gray, friable silt loam that has platy structure and is about 8 inches thick. The subsoil extends to a depth of about 4½ feet and is dark-gray and gray, firm to very firm silty clay, mottled somewhat with olive. It has subangular blocky structure. The substratum is pale-olive, firm, massive light silty clay.

Humeston soils have high available moisture capacity. The fine-textured subsoil is very slowly permeable. The content of organic matter in the surface layer is high. Humeston soils generally are low in available nitrogen, medium in phosphorus, and high in potassium. They typically are slightly acid or medium acid.

Representative profile of Humeston silt loam on a slope of about 1 percent (43 feet east and 1,980 feet south of the northwest corner of the NE¼NE¼ sec. 34, T. 76 N., R. 37 W.):

Ap—0 to 7 inches, black (10YR 2/1) heavy silt loam that is very dark brown (10YR 2/2) when crushed; moderate, fine, subangular blocky and weak, fine, granular structure; friable; a few very fine roots; slightly compacted; medium acid; clear boundary.

A12—7 to 11 inches, black (10YR 2/1) heavy silt loam that is very dark brown (10YR 2/2) when crushed; a few, medium, faint mottles of dark gray (10YR 4/1); moderate, fine, subangular blocky structure; friable to firm; a few very fine roots; medium acid; clear boundary.

A2—11 to 19 inches, dark-gray (10YR 4/1) silt loam; a few, fine, faint mottles of dark yellowish brown (10YR 4/4) are on some peds; weak, medium, platy structure that breaks to moderate, fine, subangular blocky; friable; mottles are generally concentrated in the lower part of the horizon; medium acid; abrupt boundary.

B21tg—19 to 30 inches, dark-gray (10YR 4/1) and gray (10YR 5/1) light silty clay that is gray (10YR 5/1) when crushed; moderate, medium, subangular blocky structure; firm to very firm; clay films on the surfaces of vertical and horizontal peds; some very dark gray (10YR 3/1) coats are on peds; a few fine pores; slightly acid; gradual boundary.

B22tg—30 to 43 inches, gray (5Y 5/1) and dark-gray (5Y 4/1) silty clay that is dark gray (5Y 4/1) when crushed; common, medium, distinct mottles of olive (5Y 5/3); moderate, medium, subangular blocky structure; firm to very firm; clay films on surfaces of vertical and horizontal peds; black (10YR 2/1) organic material in channels; slightly acid; gradual boundary.

B3g—43 to 56 inches, dark-gray (5Y 4/1) and olive (5Y 5/3) silty clay that is gray (5Y 5/1) when crushed; weak, coarse, subangular blocky structure; firm to very firm; many dark stains and many dark root fillings in channels; slightly acid; gradual boundary.

C1—56 to 62 inches, pale-olive (5Y 6/3) light silty clay; a few, fine, faint mottles of yellowish brown (10YR 5/8); massive with some vertical cleavage; firm; black organic stains and channel fillings; slightly acid.

The surface layer of Humeston soils is black to very dark gray and is 8 to 14 inches thick. It overlies a dark-gray to gray layer that is 8 to 10 inches thick. The subsoil typically is dark gray or gray, and its clay content is 45 to 55 percent. In places in the lower part of the subsoil and in the substratum, the color is grayish brown to olive gray or olive. Dark grayish-brown and yellowish-brown mottles are common in the subsoil and substratum, and they generally increase in size and number with depth.

Humeston soils are similar to the Bremer and Zook soils, but those soils lack the distinct, light-colored subsurface horizon typical of Humeston soils. These soils have a finer textured subsoil than Corley soils. Also in many places they are shallower to the zone of maximum clay accumulation, and the increase in clay from the subsurface layer to the subsoil is more abrupt.

Humeston silt loam (0 to 2 percent slopes) (Hu).—This is the only Humeston soil mapped in the county. Individual areas generally are between 3 and 10 acres in size. The profile of this soil is like the one described as representative for the series.

Most areas of this soil are small and generally are farmed along with surrounding soils. Cultivated crops are grown in most places, but some of the wettest areas are left in pasture. This soil generally is wet in spring and is difficult to work. It dries slowly, and in many places tillage is delayed. Surface drainage is needed. Tile drains do not work well, because water moves slowly in the subsoil. Productivity is only moderate, even if this soil is drained, and in wet years it is likely to be low. Pasture is a good use for areas not drained. Capability unit IIIw-1.

Judson Series

In the Judson series are dark-colored soils that are well drained to moderately well drained. These soils formed under prairie grasses in local alluvium in places where water from upland drainageways flows onto bottom lands. The alluvium consists of silty material washed from adjacent slopes over a long period of time. Slopes range from 0 to 9 percent, but in most places they are 0 to 5 percent.

Judson soils generally are on foot slopes below the Marshall and Sharpsburg soils and extend downslope to soils on low stream benches on bottom lands. They are also on alluvial fans. They occur in all parts of the county. In places Judson soils are closely associated with Colo soils and are mapped in a complex with those soils.

The surface layer is very dark brown or black, friable heavy silt loam that has fine subangular blocky structure and is about 2 feet thick. It overlies dark-brown, friable light silty clay loam that in some places has very dark grayish-brown colors on the exteriors of the soil peds. This transitional layer is about 12 inches thick, if present, but in places it is lacking. The subsoil to a depth of about 60 inches is dark-brown, friable light silty clay loam that has a few dark yellowish-brown mottles. It has weak prismatic structure that breaks to subangular blocky.

Judson soils have high available moisture capacity and high content of organic matter. Permeability of the subsoil is moderate. Runoff causes gully erosion in some places. These soils receive fresh deposits of material in areas where they are adjacent to the base of upland slopes. Judson soils are medium in available nitrogen and phosphorus, are high in potassium, and are slightly acid to medium acid. They are suitable for row crops. Protection from overflow and from deposition are the most important management problems.

Representative profile of Judson silt loam on a 2 percent slope facing north-northeast (389 feet north and 474 feet east of the southeast corner of the SW¼SE¼ sec. 31, T. 77 N., R. 37 W., on a large alluvial fan west of the East Nishnabotna River and of Indian Creek):

Ap—0 to 7 inches, black (10YR 2/1) heavy silt loam that is black (10YR 2/1) to very dark brown (10YR 2/2) when crushed and is dark gray (10YR 4/1) when dry; cloddy, but breaks to weak, fine, granular and weak, very fine, subangular blocky structure; friable; medium acid; clear, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) to very dark brown (10YR 2/2) heavy silt loam that is very dark brown (10YR 2/2) when crushed and is dark grayish brown (10YR 4/2) when dry; moderate, fine, subangular blocky structure; friable; many very fine pores and a few, fine, tubular pores; medium acid; gradual, smooth boundary.

A13—15 to 23 inches, very dark brown (10YR 2/2) heavy silt loam that is very dark grayish brown (10YR 3/2) to dark brown (10YR 3/3) when crushed and is grayish brown (10YR 5/2) when dry; a few of the ped exteriors are very dark grayish brown (10YR 3/2); moderate, fine, subangular blocky structure; friable; many very fine pores and a few, fine, tubular pores; a few black (10YR 2/1) worm casts; medium acid; gradual, smooth boundary.

AB—23 to 36 inches, dark-brown (10YR 3/3) light silty clay loam, grayish brown (10YR 5/2) when dry; some ped exteriors are very dark grayish brown (10YR 3/2) especially in the upper part of the horizon; weak prismatic structure that breaks to weak, fine, subangular blocky; friable; many very fine pores and a few, fine, tubular pores; medium acid; diffuse, smooth boundary.

B21—36 to 47 inches, dark-brown (10YR 3/3) light silty clay loam; a few, fine, faint mottles of dark yellowish brown (10YR 4/4) that are hardly visible when moist; weak prismatic structure that breaks to weak, fine, subangular blocky; a few, fine, very dark brown (10YR 2/2) spots of soft oxides; friable; many very fine pores and a few, fine, tubular pores; medium acid; diffuse, smooth boundary.

B3—47 to 60 inches, dark-brown (10YR 3/3) light silty clay loam; a few, fine, faint mottles of dark yellowish brown (10YR 3/4 and 4/4), which increase slightly in number with depth; weak subangular blocky structure in the upper part of the horizon but mostly massive below; friable; many very fine pores and a few, fine, tubular pores.

These soils are black to very dark brown to a depth between 20 and 30 inches. In areas that have recent overwash on them, however, the plow layer is very dark grayish brown. The soils grade to dark brown or brown with depth. Mottles generally are not present above a depth between 30 and 36 inches, but dark grayish-brown to yellowish-brown mottles occur in places below that depth. Judson soils typically are heavy silt loam to light silty clay loam in the upper part and light silty clay loam in the subsoil and underlying material. The content of sand is low.

Judson soils have a lower content of sand than Olmitz soils. Their subsoil is somewhat finer textured than that in Kennebec soils, and they are not so dark colored as those soils between a depth of 30 and 40 inches.

Judson silt loam, 0 to 2 percent slopes (JdA).—This soil is on alluvial fans below upland drainageways (fig. 6). The areas generally are between 5 and 20 acres in size and occur throughout the county.

Included with this soil are some areas that have 6 to 16 inches of recent overwash on the surface. This overwash consists of dark grayish-brown silt loam.

This Judson soil can be used frequently for row crops. It generally is cropped along with soils on adjacent benches and bottom lands. If this soil is cropped intensively, plowing under crop residues and providing protection from runoff are ways to help maintain productivity. Capability unit I–2.

Judson silt loam, 2 to 5 percent slopes (JdB).—Some areas of this soil are long and narrow and are on concave foot slopes below Marshall and Sharpsburg soils. Other

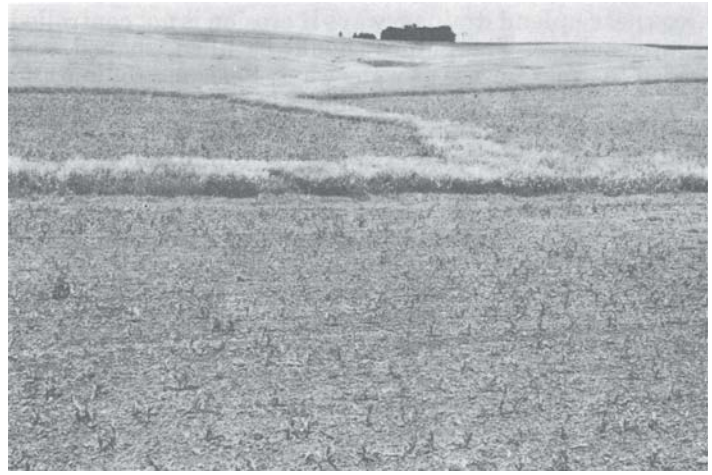

Figure 6.—**Judson silt loam, 0 to 2 percent slopes, is in the foreground; the grassed waterway farther back extends through an area of Judson-Colo complex, 2 to 5 percent slopes. The strongly sloping area in the background consists of Marshall soils.**

areas are on alluvial fans that extend onto low alluvial stream benches and first bottoms. Individual areas range from about 5 to 50 acres, and they occur in all parts of the county.

This is the most extensive Judson soil mapped separately in the county. Its profile is like the one described as representative for the series. This soil is in good tilth. It is easy to work in seasons when rainfall is normal. Some areas are subject to flooding and severe gullying if not protected.

Included with this soil are a few areas that have 6 to 16 inches of recent deposition on the surface. These deposits consist of dark grayish-brown silt loam that has a low content of organic matter. They were washed from adjacent uplands, and the deposition is most common near the base of slopes and adjacent to drainageways.

This Judson soil can be used frequently for row crops. It generally is cropped the same as adjoining soils on benches and bottom lands.

If row crops are grown on this soil, contour farming is needed. Plowing under all crop residues helps to keep the soil in good tilth when cropped intensively. Constructing terraces on nearby upland slopes and placing diversion terraces at the base of adjacent side slopes are ways to prevent damage from overflow and deposition. Water from runoff is likely to accumulate at the upper edges of the soil areas. Placing interceptor tile in such areas helps to dispose of excess water. Capability unit IIe–2.

Judson silt loam, 5 to 9 percent slopes (JdC).—This soil is on low foot slopes that border upland drainageways. The areas are below Marshall and Sharpsburg soils. Individual areas range from about 5 to 15 acres and are scattered throughout most of the county.

The surface layer of this soil is black to very dark brown. It is 20 to 24 inches thick.

Included with this soil are some areas of Marshall and Sharpsburg soils that are too small to be mapped separately.

Most areas of this Judson soil are cultivated. Row crops can be grown much of the time if erosion is controlled.

Farming on the contour and terracing this soil are ways to help control erosion. Deep gullies are likely to form in areas near upland drainageways if erosion is not controlled in areas above. The gullies should be filled, shaped, and seeded to grass for use as waterways. Response to lime and fertilizer is good. Capability unit IIIe–1.

Judson-Colo complex, 2 to 5 percent slopes (JoB).—The soils of this complex are along small upland drainageways throughout the county. Judson silt loam, 2 to 5 percent slopes, and Colo silty clay loam are the dominant soils, and each is described in detail under their respective series. The Judson soil generally is at the base of slopes, and the Colo soil typically is adjacent to channels of drainageways. The soils of this complex are associated with all soils of the uplands, as well as with those on stream benches and on bottoms. They are near Olmitz soils in some areas underlain by glacial till.

Soils of this complex are dark colored and are well drained to poorly drained. Many areas are cut by meandering channels and by gullies. A few areas are severely channeled, and further gullying is likely because of runoff. Permeability of the subsoil is slow, and many areas are wet and seepy. Many areas close to drainageways have 6 to 16 inches of recent, silty sediment on the surface.

Included with this complex are some areas of a soil that has a clayey subsoil. The areas are too small to be mapped separately.

Most areas of this complex are narrow and are cropped along with surrounding soils of the uplands. The crops are those commonly grown in the county. Many areas are in permanent pasture. These generally occupy areas where the surrounding soils are not suited to cultivation or the part on bottom lands is cut by channels or is severely gullied.

If drainage is provided and gullying controlled, these soils can be used frequently for row crops. The areas also are well suited to pasture. Tile drains can be used to improve wet, seepy areas. Farming on the contour and constructing terraces in the soils upslope help to control gullying. Diversion terraces also can be used for this purpose. Gullied areas need to be filled and seeded to grass for use as waterways. Capability unit IIw–1.

Kennebec Series

The Kennebec series consists of nearly level, dark-colored soils that are moderately well drained to somewhat poorly drained. These soils formed under prairie grasses in silty alluvium. They are on first bottoms throughout the county along most of the major streams and their tributaries. They are associated with the Colo, Nodaway, and Zook soils.

The surface layer is chiefly black or very dark brown, friable silt loam that has fine granular and fine subangular blocky structure. It is about 30 inches thick. The subsoil is black to very dark brown, friable light silty clay loam to a depth of 40 inches and very dark gray, friable silty clay loam below that depth. Structure is subangular blocky.

These soils have high available moisture capacity and high content of organic matter. Permeability of the subsoil is moderate. Protection from overflow is desirable, but tile drains are seldom needed. Straightening the stream channels partly eliminates the hazard of overflow. Kennebec soils are low in available nitrogen, medium to high in phosphorus and in available potassium, and slightly acid to medium acid.

Representative profile of Kennebec silt loam on a slope of about 1 percent (160 feet west and 470 feet north of the southeast corner of sec. 34, T. 75 N., R. 36 W.):

A1—0 to 3 inches, very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) silt loam; fine granular structure; friable; a few fine pores; many fine roots; medium acid; clear boundary.

A12—3 to 9 inches, black (10YR 2/1) silt loam; weak, very fine and fine, granular structure; friable; a few fine pores; many very fine roots; medium acid; clear boundary.

A13—9 to 18 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silt loam; weak, very fine, subangular blocky structure that breaks to weak, medium, granular; friable; many fine pores; a few very fine roots; slightly acid; clear boundary.

A31—18 to 24 inches, black (10YR 2/1) silt loam that is black (10YR 2/1) or very dark gray (10YR 3/1) when crushed; moderate, fine, subangular blocky structure; friable; many fine pores; a few very fine roots; many wormholes: a few root channels; slightly acid; gradual boundary.

A32—24 to 34 inches, black (10YR 2/1) silt loam that is black (10YR 2/1) or very dark gray (10YR 3/1) when crushed; weak to moderate, fine, subangular blocky structure; friable; many fine pores; many fine wormholes; a few root channels; slightly acid; gradual boundary.

B11—34 to 40 inches, black (10YR 2/1) light silty clay loam that grades to very dark brown (10YR 2/2); weak to moderate, fine, subangular blocky structure; friable; a few fine pores; a few fine wormholes; slightly acid; clear boundary.

B12—40 to 45 inches, very dark gray (10YR 3/1) light silty clay loam that grades to very dark brown (10YR 2/2); weak to moderate, medium, subangular blocky structure; friable; a few fine pores; a few fine wormholes; slightly acid; clear boundary.

B2—45 to 55 inches, very dark gray (10YR 3/1) silty clay loam; moderate, medium, subangular blocky structure; friable; a few fine pores; slightly acid.

Kennebec soils generally are black or very dark brown to a depth of 40 inches or more. In places at a depth below 30 inches the color grades to very dark gray. In areas that have recent deposition on them, the upper few inches are very dark grayish brown to dark grayish brown. The texture below a depth of 30 inches ranges from silt loam to light silty clay loam. In some places fine, dark-brown mottles are at a depth below 36 inches.

Kennebec soils are darker colored than Nodaway soils and lack the distinct stratification typical of those soils. They are better drained than Colo and Zook soils and are not so fine textured.

Kennebec silt loam (0 to 2 percent slopes) (Ke).—This is the only Kennebec soil mapped in the county. It occupies both narrow and wide areas on bottom lands throughout the county. Individual areas are as much as 150 acres in size.

The profile of this soil is like the one described as representative for the series. In about one-third of the area sediment has been washed onto the surface. The sediment consists of dark grayish-brown silt loam that is 6 to 16 inches thick.

Included with this soil are some areas of Colo and Nodaway soils. These soils are too small to be mapped separately.

Some areas of this Kennebec soil are large enough to be farmed separately, but many areas are cropped the same as other surrounding soils on bottom lands. Most areas are cultivated. Row crops can be grown frequently. In a few places flooding, and possibly a temporary perched water table, may cause wetness in years when rainfall is above normal. Such areas, however, generally are not wet enough to need tile drainage. Growing a meadow crop in the rotation occasionally helps to keep the soil in good tilth. Crops on this soil respond well if lime and fertilizer are applied. Capability unit I–2.

Ladoga Series

The Ladoga soils are moderately dark colored and are well drained or moderately well drained. These soils formed in loess under trees and prairie grasses. Slopes range from 2 to 25 percent. Some areas are on gently sloping ridgetops and moderately sloping to steep side slopes. Others are on stream benches on loess. The areas are strongly dissected and border the major streams of the county. They generally are on slopes that face north and west and have a cover of scattered trees and grasses. Small outcrops of sandstone and shale occur along the base of slopes adjacent to the East Nishnabotna River, near Lewis. These are shown on the detailed soil map by a spot symbol.

Ladoga soils are associated with the Adair and Shelby soils and with the Gara and Sharpsburg soils throughout the county. In many places in the western part of the county, they are on the same slope as Marshall and Shelby soils.

The surface layer is very dark gray, friable silt loam that has fine granular structure and is about 4 inches thick. It overlies dark grayish-brown, friable silt loam that has platy structure. The subsoil extends to a depth of about 4 feet or more. It is mainly dark-brown to brown and yellowish-brown, firm heavy silty clay loam that in some places has yellowish-brown, olive-gray, and brown mottles. Structure is angular blocky and subangular blocky.

Ladoga soils have high available moisture capacity. Permeability of the subsoil is moderately slow. In cultivated areas material from the subsurface layer has been mixed with the surface layer. As a result, in these areas the surface layer is grayish when dry. Ladoga soils are low to very low in available nitrogen, medium to low in phosphorus, and medium in potassium. They typically are medium acid to strongly acid in the subsoil, but they range from slightly acid to very strongly acid in the upper layers.

These soils erode readily if not protected, and terraces or contour farming are needed. Tilth is fairly good if the subsoil is not exposed. In many places gullies have formed in the sides of hills in areas overcropped or overgrazed.

Representative profile of Ladoga silt loam on a 12 percent slope that faces northwest (southwest 5 acres of the SW¼SE¼SW¼ sec. 14, T. 76 N., R. 36 W.):

A1—0 to 4 inches, very dark gray (10YR 3/1) silt loam; moderate, fine and very fine, granular structure; friable; slightly acid; clear boundary.

A2—4 to 8 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, thin, platy structure; friable; peds have very dark gray (10YR 3/1) exteriors and gray to light-gray (10YR 6/1, dry) silty coatings; a few worm casts; very strongly acid; abrupt boundary.

B1—8 to 14 inches, dark grayish-brown (10YR 4/2) and very dark gray (10YR 3/1) silty clay loam; moderate, fine, granular and very fine, subangular blocky structure; friable; prominent, light-gray (10YR 7/1, dry) silty coatings on peds; a few worm casts; very strongly acid; clear boundary.

B21—14 to 18 inches, dark-brown to brown (10YR 4/3) heavy silty clay loam; strong, fine and very fine, angular blocky structure; friable to firm; continuous, gray to light-gray (10YR 6/1, dry) silty coating one peds; a few worm casts; strongly acid; abrupt boundary.

B22t—18 to 24 inches, dark-brown to brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) heavy silty clay loam; strong, fine, angular blocky structure; firm; some gray to light-gray (10YR 6/1, dry) silty coatings on peds; clay films on vertical and horizontal faces of peds; a few, fine, soft concretions of iron and manganese; a few worm casts; strongly acid; gradual boundary.

B23t—24 to 32 inches, yellowish-brown (10YR 5/4) heavy silty clay loam; strong, fine, angular blocky structure; firm; peds have dark-brown to brown (10YR 4/3) exteriors and some gray to light-gray (10YR 6/1, dry) silty coatings; clay films on horizontal faces of peds; a few, fine, soft concretions of iron and manganese; a few worm casts; strongly acid; gradual boundary.

B24—32 to 41 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) silty clay loam; common, medium, distinct mottles of light olive gray (5Y 6/2) and a few, fine, faint mottles of yellowish brown (10YR 5/6); weak, coarse, subangular blocky structure; firm; a few clay films on horizontal faces of peds; some gray to light-gray (10YR 6/1, dry) silty coatings on peds; many, medium, prominent, soft concretions of iron and manganese; strongly acid; gradual boundary.

B3—41 to 50 inches, yellowish-brown (10YR 5/4) light silty clay loam; many, coarse, faint mottles of yellowish brown (10YR 5/6); many, coarse, prominent mottles of light olive gray (5YR 6/2) and a few, fine, faint mottles of brown (10YR 5/3); weak, medium, subangular block structure; friable to firm; many, medium, distinct, soft concretions of iron and manganese; strongly acid.

In areas that are not eroded, the surface layer is black to very dark gray and is 4 to 8 inches thick. Just below is a dark grayish-brown layer that is 2 to 6 inches thick. In cultivated areas that are severely eroded, the subsurface layer has been mixed with the remaining surface layer by plowing. Here the present surface layer generally is very dark grayish brown.

The subsoil is dark brown to yellowish brown and commonly has grainy coatings of silt and thin films of clay on the exteriors of the soil peds. Yellowish-brown and light olive-gray mottles occur in the lower part of the subsoil, and their size and number increase with depth. Texture of the subsoil is silty clay loam. The maximum clay content is 36 to 40 percent in the finest part.

The underlying material typically is dark yellowish-brown to yellowish-brown silt loam to silty clay loam. In some places, however, the underlying material is olive gray or mottled yellowish brown and olive gray in color.

Ladoga soils have a thinner, lighter colored surface layer than Marshall and Sharpsburg soils. They also are more acid and have stronger structure. In addition Marshall and Sharpsburg soils lack the light-colored subsurface layer and grainy coatings on peds in the upper part of the subsoil, which are typical of Ladoga soils.

Ladoga silt loam, 2 to 5 percent slopes (LaB).—This soil is on gently sloping ridgetops in moderately wide areas. The areas are above more sloping Ladoga soils on side slopes and range from 10 to about 40 acres in size.

The surface layer of this soil is very dark gray silt loam 4 to 8 inches thick. In most cultivated areas the plow layer is very dark grayish brown and overlies a light-colored subsurface layer. Included is a small acreage in which all of the light-colored subsurface layer has been mixed with the surface layer by plowing.

Most areas of this Ladoga soil are used for row crops, and some areas are large enough to farm separately. Other areas remain in trees, brush, and grass. Some of these are suitable for crops or pasture if cleared. Sheet erosion is a hazard if this soil is cultivated and not protected.

If this soil is terraced or farmed on the contour, row crops can be grown much of the time. These practices control erosion on this soil and also help to reduce erosion on soils downslope. Management is needed that includes maintaining fertility, as well as keeping soil losses within allowable limits. Capability unit IIe–1.

Ladoga silt loam, 5 to 9 percent slopes ((LaC).—This soil is mostly on fairly broad ridgetops above more strongly sloping Ladoga and Gara soils. In some places it occupies narrow areas around side slopes below gently sloping Ladoga soils on ridges. Individual areas generally are between 5 and 50 acres in size.

The surface layer of this soil consists of 4 to 8 inches of silt loam. It generally is very dark gray, but in many cultivated areas it is very dark grayish brown. It overlies a layer of light-colored loam. This soil is only slightly eroded. It is subject to further erosion because of runoff.

This soil is suited to growing row crops for about half of the time, and much of it is cultivated. Many areas remain in permanent pasture because the surrounding soils are not suited to cultivation.

If row crops are grown on this soil, terracing and contour farming are needed. The fertility and content of organic matter can be improved by including grasses and legumes in the cropping system. In addition all crop residues should be plowed under and fertilizer applied. Gullies need to be filled in and seeded to permanent grasses. Capability unit IIIe–1.

Ladoga silt loam, 5 to 9 percent slopes, moderately eroded (LaC2).—Some areas of this soil are on narrow to fairly wide ridgetops upslope from more strongly sloping Gara and Ladoga soils. Many other narrow areas are around side slopes just below gently sloping ridgetops. The individual areas range between 10 and 60 acres in size.

The surface layer is very dark grayish-brown or very dark gray silt loam. In cultivated areas all of the light-colored subsurface layer and part of the subsoil generally are mixed with the remaining surface layer by plowing. Here the content of organic matter is low and tilth generally is poor. If the soil is worked when wet, the surface seals over and crusts. In areas that are cropped intensively and not protected from erosion, much of the rain that falls runs off and the hazard of further erosion is severe.

Included with this soil is a small acreage of severely eroded soils that have less than 3 inches of the original surface soil remaining. These areas are shown on the detailed soil map by the symbol for severe sheet erosion. Also included are a few scattered areas of moderately sloping Ladoga soils on loess-covered stream benches. These areas are narrow and occur below and around less sloping Ladoga soils on the tops of benches. They are scattered along bottoms of major streams.

Most areas of this Ladoga soil are in cultivated crops, and many areas are farmed along with less sloping Ladoga soils. Some wooded areas are pastured.

If this soil is farmed on the contour and terraced, row crops can be grown about half of the time. If needed, waterways should be shaped and seeded to grass to keep gullies from forming in the sides of hills. These sodded waterways also provide a crossway for farm implements. The response of crops can be improved by building up the content of organic matter and applying suitable kinds of fertilizer. A few wooded areas now in pasture would be suitable for crops if cleared. Many pastures can be improved by removing the trees and brush and then renovating the areas. Capability unit IIIe–1.

Ladoga silt loam, 9 to 14 percent slopes (LaD).—Some areas of this soil are on strongly sloping side slopes that extend downslope to Gara soils or to steeper Ladoga soils. Many other areas are below less sloping Ladoga soils and extend downslope to soils in narrow upland drainageways. Individual areas range from 10 to about 80 acres in size.

This soil is only slightly eroded. The surface layer is very dark gray, friable silt loam 4 to 8 inches thick. Just below is a light-colored layer. In many cultivated areas the surface layer is very dark grayish brown. The soil is easy to work but is subject to erosion when cultivated.

This soil is suitable for row crops if erosion is controlled. Many areas surrounded by soils not suitable for cultivation are left in permanent pasture. Other areas are cleared of trees and are cultivated.

If this soil is cultivated, terracing is needed to protect the areas from sheet erosion and from gullying. All tillage must be done on the contour. The response of forage crops is good. Areas in permanent pasture respond well if renovated and if properly fertilized. Capability unit IIIe–3.

Ladoga silt loam, 9 to 14 percent slopes, moderately eroded (LaD2).—This soil generally is downslope from Ladoga soils on ridgetops and upslope from Gara soils and soils of the Shelby-Adair complexes. In some places it occupies the entire side slope and extends downslope to drainageways. Individual areas range from 10 to 100 acres in size.

This is the most extensive Ladoga soil mapped in the county. Its profile is like the one described as representative for the series. In cultivated areas, the subsurface layer generally is mixed with the remaining surface layer by plowing and the plow layer has a grayish cast when dry. Fertility and content of organic matter are low in this soil.

Included with this soil are small areas of Gara and Adair soils. Also included are some areas of Shelby soils less than 2 acres in size, which are shown on the detailed soil map by a spot symbol. Other included areas consist of a few acres of a strongly sloping soil on high stream benches that have a cover of loess. These bench soils have short slopes and occupy narrow areas below and around the fairly wide, gently sloping Ladoga soils on the top of benches.

Most cultivated areas of this Ladoga soil are farmed along with more gently sloping soils upslope. Many areas, however, remain in pasture and trees.

If this soil is used for row crops, terracing is needed for control of erosion. Keeping waterways in grass prevents formation of gullies that cannot be crossed with farm machinery. Adding lime and fertilizer and seeding meadow mixtures that include legumes are ways to improve tilth. These practices also add organic matter and improve soil fertility. In many pastured areas the response of forage plants can be improved by removing the brush and trees and renovating the pastures. Capability unit IIIe–3.

Ladoga silt loam, 14 to 18 percent slopes (LaE).—Most areas of this soil are just below less sloping Ladoga soils and upslope from soils of the Gara series and of the Shelby-Adair complexes. In places this soil occupies the entire side slope and extends downslope to narrow upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. The areas range from 10 to 60 acres in size.

The surface layer of this soil is very dark gray silt loam. It generally is between 4 and 8 inches thick and overlies a light-colored subsurface layer. This soil is subject to runoff and erosion.

Most of this soil is in permanent pasture that includes a few scattered trees. This soil is poorly suited to row crops, but a row crop can be grown when establishing a stand of grasses and legumes for hay and pasture.

Farming on the contour and terracing the soils upslope provide protection from sheet and gully erosion. Under good management, including pasture renovation, the permanent pastures provide forage of good quality and have high carrying capacity. Applying lime and fertilizer helps to establish new seedings and to improve growth of grasses and legumes. Capability unit IVe-1.

Ladoga silt loam, 14 to 18 percent slopes, moderately eroded (LaE2).—This soil is on side slopes just below Ladoga soils on ridgetops and just above Gara soils and soils of Shelby-Adair complexes. In many places it occupies the entire side slope and extends downslope to upland drainageways or to valleys of major streams. Individual areas range between 10 and 75 acres in size.

The profile of this soil is much like the one described as representative for the series. In nearly a third of the areas, however, the soil is severely eroded, and less than 3 inches of the original surface soil remains. In these areas all of the subsurface layer and part of the subsoil have been mixed with the remaining surface layer by plowing. As a result, here the present surface soil is dark grayish brown to dark brown or brown in color and ranges to light silty clay loam in texture. All of this soil is subject to further erosion if cultivated.

Most areas of this soil are in permanent pasture that includes a few scattered trees. Areas that are cultivated generally are associated with less sloping soils above. This soil is poorly suited to row crops, but a row crop can be grown when establishing a stand of grasses and legumes for hay or pasture.

Farming on the contour and terracing the soils upslope protect this soil from sheet and gully erosion. Gullies that have cut into the sides of hills in many places need to be shaped and seeded to pasture. Under good management, including pasture renovation, permanent pastures provide good forage and have high carrying capacity. Adding lime and fertilizer helps to establish new seedings and to improve growth of grasses and legumes. Capability unit IVe-1.

Ladoga silt loam, benches, 2 to 5 percent slopes (LbB).—This soil is on moderately wide, loess-covered benches that fan out into and parallel the bottoms of stream valleys. It generally is below strongly sloping Gara and Ladoga soils, but in many places it is upslope from moderately sloping Ladoga soils that extend toward bottom lands. The individual areas generally are between 5 and 20 acres in size, and most of the acreage is near Atlantic and south of Cumberland.

The surface layer of this soil is very dark gray silt loam 4 to 8 inches thick. It overlies a light-colored subsurface layer. Depth to the underlying alluvium is 12 to 15 feet. In cultivated areas the plow layer in many places is very dark grayish brown.

Included with this soil are some nearly level areas that are too small to be mapped separately.

This Ladoga soil generally is farmed separately from the soils upslope and those soils downslope on bottom lands. Row crops can be grown frequently if fertility is maintained. Some nearly level areas are slightly wet, but tile drains generally are not needed.

If this soil is cultivated, farming on the contour reduces losses of this soil and also helps to prevent erosion on soils downslope. Because of the irregular slopes, terracing generally is not suitable. Crops respond if adequate amounts of fertilizer are applied and if the soil is otherwise well managed. Capability unit IIe-1.

Ladoga soils, 9 to 14 percent slopes, severely eroded (LdD3).—These undifferentiated soils are just below less sloping Ladoga soils on ridgetops. They generally are upslope from Gara soils and from soils of the Shelby-Adair complexes, but in some places they are above upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. Individual areas are between 10 and 40 acres in size.

The surface layer of these soils is dark grayish-brown to dark-brown or brown silt loam to silty clay loam. It is 3 inches or less thick. In cultivated areas all of the light-colored subsurface layer and part of the subsoil have been mixed with the remaining surface layer by plowing. These soils are subject to severe sheet and gully erosion. They are low in organic matter, runoff is rapid, and they absorb moisture slowly.

Included with these soils are some soils on glacial material, such as soils of the Adair and Gara series and soils of Shelby-Adair complexes. These soils are in areas too small to be mapped separately.

These Ladoga soils are better suited to pasture than to crops, but many small areas are farmed with surrounding soils that are better suited to crops. Growing of row crops should be done only when establishing a stand of hay or pasture. Gullies in the sides of hills need to be shaped, smoothed, and seeded to permanent grasses. Farming on the contour and terracing soils upslope are ways to protect these soils from further sheet and gully erosion. Applying manure helps to build up the content of organic matter. Capability unit IVe-1.

Ladoga soils, 14 to 18 percent slopes, severely eroded (LdE3).—These undifferentiated soils generally are downslope from less sloping Ladoga soils and upslope from Gara soils. In many places they occupy the entire side slope and extend downslope to drainageways or stream valleys. Individual areas generally are small and range between 5 and 30 acres.

The surface layer is very dark gray to dark grayish-brown silt loam or light silty clay loam. It generally is no more than 3 to 5 inches thick and overlies a light-colored subsurface layer. In places all of the subsurface layer and part of the subsoil are mixed with the remaining surface layer.

Included with these soils are some areas that have a surface layer of very dark gray loam that is 4 to 8 inches thick. These included areas are too small to be mapped separately. Also included are a few areas that have slopes of 18 to 25 percent.

These Ladoga soils are not suited to cultivated crops, because of the severe hazard of further erosion. Permanent pasture is a good use, and most areas are in woodland pasture. In many areas the soils are unproductive, because of excessive tillage on areas not protected. The subsoil is exposed in much of the acreage, and tilth therefore, is poor.

Farming on the contour and terracing the soils upslope help to prevent further erosion. Pastured areas need to be cleared of trees and undergrowth and then renovated. Gullies in the areas need to be shaped and seeded to grass. These grassed areas provide forage and also permit more efficient use of farm machinery. Capability unit VIe–1.

Marsh

Marsh (Ma) consists of low areas that remain wet or are under water for most of the year. Cattails, sedges, willows, and other plants that tolerate wetness grow in these marshy places. The areas are low and are scattered mainly along Turkey Creek, but some are along the East Nishnabotna River. Individual areas generally are between 10 and 40 acres in size.

Marsh has no value for farming. Overflow from the streams stands on the areas because drainage outlets are lacking. Furthermore, the areas are difficult to drain because the grade of the channels of the adjacent streams is flat. Marsh generally is too wet for pasture plants. Wildlife habitats are a good use. Capability unit VIIw–1.

Marshall Series

In the Marshall series are deep, dark-colored soils that are well drained. These soils formed under prairie grasses in loess. Slopes range from 0 to 18 percent.

Marshall soils are the most extensive soils in the uplands in the county. They occupy variable topographic positions in the western two-thirds of the county. Some areas are on nearly level divides; other areas occupy the entire side of a slope; and still other areas are on high stream benches. These soils are associated with the Adair, Clarinda, Hagener, Ladoga, and Shelby soils. They also are associated with all other soils in the uplands in the western two-thirds of the county.

The surface layer is black to very dark brown in the upper part and grades to very dark brown and very dark grayish brown in the lower part. It is about 18 inches thick. The texture is silty clay loam, and the structure is mainly fine granular and fine and medium subangular blocky. The subsoil, which extends to a depth of about 4 or 5 feet, is friable silty clay loam and has subangular blocky structure. It is dark brown to brown in the upper part and mottled yellowish brown, grayish brown, and dark brown to brown in the lower part. The substratum is friable, massive silt loam. It is mottled dark brown to brown, yellowish brown, strong brown, and olive gray in color.

These soils have high available moisture capacity. The content of organic matter ranges from high, in the nearly level soils that have a thick surface layer, to moderately low, in the steeper, eroded soils. Permeability of the subsoil is moderate. Available nitrogen is medium to low in the gently sloping soils and low in the steeper, eroded ones. Available phosphorus is low in the steep soils and medium in the less sloping ones. All Marshall soils are high to medium in available potassium and generally are slightly acid or medium acid. Some areas less than 2 acres in size have less than 3 inches of the original surface soil remaining. These severely eroded areas are shown on the detailed soil map by a spot symbol.

Marshall soils are the most important soils in the county for farming. They are more productive than any other upland soil in the county. These soils, however, are subject to sheet and gully erosion, and productivity decreases with the steepness of the slope and the amount of erosion. If the slopes permit, farming on the contour and terracing are suitable practices for controlling erosion.

Representative profile of Marshall silty clay loam on a slope of about 3 percent that faces west (829 feet south of the center of the road and 500 feet east of the northwest corner of the NW¼SE¼ sec. 34, T. 77 N., R. 37 W.):

Ap—0 to 7 inches, black (10YR 2/1) to very dark brown (10YR 2/2) light silty clay loam that is dark gray (10YR 4/1) to grayish brown (10YR 5/2) when dry and very dark brown (10YR 2/2) when kneaded; weak, medium, subangular blocky structure that breaks to weak, fine, granular; friable; common, fine and medium, root channels; a few very dark grayish-brown (10YR 3/2) worm casts; medium acid; clear, smooth boundary.

A12—7 to 13 inches, very dark brown (10YR 2/2) light silty clay loam that is grayish brown (10YR 5/2) to pale brown (10YR 6/3) when dry and very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) when kneaded; weak, fine, granular and weak, fine, subangular blocky structure; friable; common, fine and medium, root channels; a few very dark grayish-brown (10YR 3/2) worm casts; medium acid; gradual, smooth boundary.

A3—13 to 18 inches, very dark grayish-brown (10YR 3/2) medium silty clay loam that is grayish brown (10YR 5/2) and has some peds that are pale brown (10YR 6/3) when dry; weak, fine, subangular blocky structure; friable; common, fine, inped tubular pores and some medium root channels; a few peds; pore fillings and worm casts are dark brown to brown (10YR 4/3); medium acid; clear, wavy boundary.

B21—18 to 26 inches, dark-brown to brown (10YR 4/3) medium silty clay loam that is pale brown (10YR 6/3) when dry; weak to moderate, fine, subangular blocky structure; friable; common, fine, inped tubular pores; some oriented, thin, discontinuous stains of very dark grayish brown (10YR 3/2) on a few peds; a few black (10YR 2/1) fillings in fine vertical channels; a few, very fine, soft, dark-brown concretions of an oxide; medium acid; gradual, smooth boundary.

B22—26 to 34 inches, dark-brown to brown (10YR 4/3) light to medium silty clay loam; a few, fine, grayish-brown (2.5Y 5/2) mottles; weak, medium, prismatic structure that breaks to moderate, fine, subangular blocky; friable; many, fine, inped tubular pores; thin, discontinuous clay films on some peds; a few, fine, soft, dark-brown and yellowish-brown concretions of an oxide; medium acid; clear, smooth boundary.

B31—34 to 41 inches, yellowish-brown (10YR 5/4) and dark-brown to brown (10YR 4/3) light silty clay loam; common, fine, grayish-brown (2.5Y 5/2) and common, fine, yellowish-brown (10YR 5/6) mottles that grade to dark brown to brown (7.5YR 4/4); weak, medium, prismatic structure that breaks to moderate and weak, medium, subangular blocky; friable; many, fine, inped tubular pores; thin, discontinuous clay films on vertical faces of peds; a few, fine, soft, dark-brown and yellowish-brown concretions of an oxide; slightly acid; gradual smooth boundary.

B32—41 to 47 inches, mottled yellowish-brown (10YR 5/4), grayish-brown (2.5Y 5/2), and dark-brown to brown (10YR 4/3) light silty clay loam; common, fine mottles of yellowish brown (10YR 5/6) and dark brown to brown (7.5YR 4/4); weak, medium, prismatic structure that breaks to weak, medium, subangular blocky; friable; many, fine and medium, inped tubular pores; a few, thin, continuous films on the vertical faces of some peds (may be clay); slight increase in grayish brown color in ped interiors; a few, very fine, soft, black concretions of an oxide; slightly acid; gradual, smooth boundary.

B33—47 to 58 inches of light silty clay loam to heavy silt loam, the same color as the B32 horizon except the grayish-brown colors grade to olive gray (5Y 5/2); weak, medium to coarse, prismatic structure that breaks to weak, medium, subangular blocky; common, fine mottles of yellowish brown (10YR 5/6) and dark brown to brown (7.5YR 4/4); friable; many, fine and medium, inped tubular pores; a few, very fine, soft, black concretions of an oxide; a few, indistinct, grainy coats of silt on a few vertical faces; neutral; diffuse, smooth boundary.

C1—58 to 68 inches, mottled yellowish-brown (10YR 5/4 to 5/6) and olive-gray (5Y 5/2) silt loam; massive with some vertical cleavage; friable; many, fine and very fine, tubular pores; a few, indistinct, grainy coats of silt on vertical faces; a few, fine, soft, dark-brown to black concretions of an oxide; neutral; clear, smooth boundary.

C2—68 to 72 inches, mottled dark-brown to brown (7.5YR 4/4), strong-brown (7.5YR 5/6), and some olive-gray (5Y 5/2) silt loam; massive with some vertical cleavage; friable; many, fine and very fine, tubular pores; a few, indistinct, grainy coats of silt on vertical faces; common, fine, soft, dark-brown to black concretions of an oxide; neutral; clear, smooth boundary.

C3—72 to 76 inches, mottled, dark yellowish-brown (10YR 4/4), yellowish-brown (10YR 5/6), and olive-gray (5Y 5/2) silt loam; massive; friable; a few, fine, soft, dark-brown to black concretions of an oxide; neutral.

The surface layer typically is 8 to 16 inches thick in nearly level soils or in soils that have not been severely eroded, but it is as little as 3 inches thick in severely eroded soils. This layer is black to very dark brown and very dark grayish brown. The subsoil typically is dark-brown to yellowish-brown silty clay loam that has a clay content of 20 to 35 percent. A few mottles of yellowish brown, dark brown, or olive gray generally are at a depth below 30 inches. The underlying material generally is brown or yellowish-brown silt loam and has common, grayish or strong-brown mottles.

The thickness of the loess in which the Marshall soils formed ranges from nearly 35 feet in the northwest corner of the county to from 15 to 20 feet in the southeastern part of the Marshall association. In areas where the Marshall soils are closely associated with the Ladoga soils, some Marshall soils formed partly under trees. Here the material just below the surface layer is darker brown than in typical Marshall soils and the subsoil is a little finer textured.

Marshall soils have a thinner surface layer than Minden soils, and their subsoil lacks the grayish-brown colors typical of those soils. They contain less clay than Sharpsburg soils, their subsoil lacks the increase in clay typical of those soils, and depth to mottling is greater.

Marshall silty clay loam, 0 to 2 percent slopes (MhA).—This soil is on broad, nearly level ridgetops scattered throughout the Marshall association. It generally is surrounded by Marshall silty clay loam, 2 to 5 percent slopes.

The surface layer of this soil is black to very dark brown. It is as much as 20 inches thick. Depth to grayish-brown and yellowish-brown mottles generally is less than in more sloping Marshall soils.

Included with this soil are a few areas of nearly level Minden soils. These included soils are in areas too small to be mapped separately.

Under good management row crops can be grown frequently on this Marshall soil. Growing a meadow crop occasionally in the cropping system and returning crop residues to the soil help to maintain the generally high content of organic matter. These practices also keep the soil in good tilth. In many places this soil is farmed along with other Marshall soils and with Minden soils because individual areas generally are only 15 to 30 acres in size. In Pleasant Township, however, some areas occupy as much as 100 acres or more, and some of these are farmed separately. This soil may be more leached of lime than other Marshall soils, and soil tests are needed to determine the amount of lime required. Capability unit I–1.

Marshall silty clay loam, 2 to 5 percent slopes (MhB).—This soil is on fairly broad ridgetops in the Marshall association. In places it extends for a mile or more along some of the ridges or divides. It is below the higher lying, nearly level Marshall soils on broader ridgetops and above the higher lying, more sloping Marshall soils on side slopes.

The profile of this soil is like the one described as representative for the series. This soil is in excellent tilth. The content of organic matter is high. Erosion is a hazard.

Included with this soil are some areas of a soil that has only 3 to 7 inches of the original surface soil remaining. Also included are many areas that have slopes of less than 2 percent. These included soils are in areas too small to be mapped separately.

This Marshall soil is used for row crops much of the time, to which it is well suited. Good management, including terracing and farming on the contour, is needed for control of erosion. Terracing this soil also helps to protect the soils downslope. Some areas of this soil are large enough to be farmed separately, though most areas are cropped along with surrounding soils that are more sloping. Capability unit IIe–1.

Marshall silty clay loam, 5 to 9 percent slopes (MhC).—This soil occupies many fairly narrow divides or crest of ridges that occur throughout the Marshall association. In many places it occupies the entire side of a slope just below gently sloping ridgetops. In many places where the bottom part of the side slope is on glacial till, rather than loess, this soil is upslope from Shelby soils.

The surface layer of this soil is black to very dark brown silty clay loam. It is 8 to 14 inches thick. Workability of this soil is good, but erosion is a severe hazard if the areas are not protected.

This soil is well suited to row crops, and a few areas are large enough to be farmed separately. Other areas are cultivated along with surrounding soils. Some areas are pastured because they are small and are adjacent to soils not so well suited to cultivation.

If this soil is cultivated, terracing and farming on the contour are needed to reduce losses of soil and water. Grassed waterways also are needed to prevent gullies from forming and to provide a crossing for farm machinery. Capability unit IIIe–1.

Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded (MhC2).—This soil occupies positions on the landscape similar to those occupied by Marshall silty clay loam, 5 to 9 percent slopes, and is associated with the same soils. Some of the areas are as large as 80 acres.

The surface layer of this soil is only 3 to 7 inches thick. It is very dark brown or very dark grayish brown in color. In places material formerly in the subsoil has been mixed with the surface layer. The content of organic matter is lower than in less eroded soils.

This soil is suited to row crops, and a few areas are large enough to be farmed separately. Many areas are farmed with other surrounding Marshall soils.

If this soil is used for row crops, fertility must be kept high, erosion controlled, and other good management used. Using a cropping system that includes grasses and legumes improves tilth, increases the capacity to absorb rainfall, and reduces the hazard of erosion. Terracing (fig. 7) and farming on the contour prevent further soil losses. Any shallow gullies in the areas need to be filled, smoothed, and seeded to grass for use as waterways. The sodded waterways also provide a crossing for farm machinery. Capability unit IIIe-1.

Marshall silty clay loam, 5 to 9 percent slopes, severely eroded (MhC3).—This soil is on the lower part of narrow divides and extends upward to less sloping Marshall soils where the ridgetops widen out. Downslope are more strongly sloping soils on loess and glacial till. Individual areas range from 10 to 30 acres in size.

All but 3 inches or less of the very dark grayish-brown original surface layer of this soil has been removed through erosion as the result of past intensive cropping. In many places the dark-brown subsoil is exposed. The present surface layer is low in organic matter, puddles when wet, and is cloddy and hard when dry. It therefore is in poor tilth. The soil absorbs water slowly, and runoff is excessive.

This soil generally is used for crops. It usually is cropped the same as surrounding soils. Terracing and contour farming are needed. A cropping system that includes grasses and legumes also is needed for building up soil fertility and for reducing further losses of soil. Gullies in the sides of hills must be filled and seeded to grasses for use as waterways for the control of runoff. Adding manure and applying fertilizer improve soil fertility and tilth. These practices also help to maintain productivity. Capability unit IIIe-1.

Marshall silty clay loam, 9 to 14 percent slopes (MhD).—In many places this soil occupies the entire side of a slope and extends downslope to upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. The areas generally are downslope from less sloping Marshall soils. In some places, however, Adair or Shelby soils are downslope. Individual areas range between 10 and 60 acres in size.

The surface layer of this soil generally is very dark brown in color and is 7 to 12 inches thick. Depth to the underlying parent material of silt loam is within 40 inches, which is less than in less sloping Marshall soils. The content of organic matter is fairly high, and the capacity to absorb moisture is good. Gullies form readily in the sides of hills if the areas are not protected from excessive runoff.

Most of this soil is cultivated along with other soils with which it is associated. A few areas that are associated with less productive or steeper soils are used for pasture.

If this soil is terraced and tilled on the contour, it is suited to cultivated crops. A cropping system that includes grasses and legumes is needed to keep fertility high and to maintain productivity. Any gullies in the areas need to be shaped and seeded to grass for use as waterways that will remove excess water. Terracing the soils upslope helps to reduce the volume of runoff water. Capability unit IIIe-3.

Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded (MhD2).—This soil generally occupies the entire side of a slope and extends downslope to stream bottoms and upland drainageways. In a few places it occupies narrow areas between higher lying Marshall soils and lower lying soils on glacial till. About 80 acres of this soil is along the East Nishnabotna River in scattered areas on high stream benches that have a cover of loess. These areas on benches are mainly narrow breaks between less sloping Marshall soils and soils of the bottom lands.

This is the most extensive Marshall soil mapped in the county. All but 3 to 7 inches of the very dark grayish-brown to dark-brown original surface layer has been lost through erosion. In places material from the subsoil has been mixed with the remaining surface layer by plowing. The subsoil is slightly thinner than in less sloping Marshall soils. Depth to the silt loam parent material generally is within 40 inches.

Some areas of this soil on the lower part of slopes have a cover of dark-colored, silty material that washed onto the areas from the shoulders of slopes above. In some places near drainageways and near the boundaries of the upper part of slopes, the subsoil is exposed.

Tilth of this soil is fair to poor. In some areas water is absorbed fairly slowly. Here the soil puddles and is cloddy if worked when wet.

This soil is suited to cultivated crops, and most areas are under cultivation. If row crops are grown, terracing and farming on the contour are needed (fig. 8). Fertility must

Figure 7.—**Terraces constructed in the fall on Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded.**

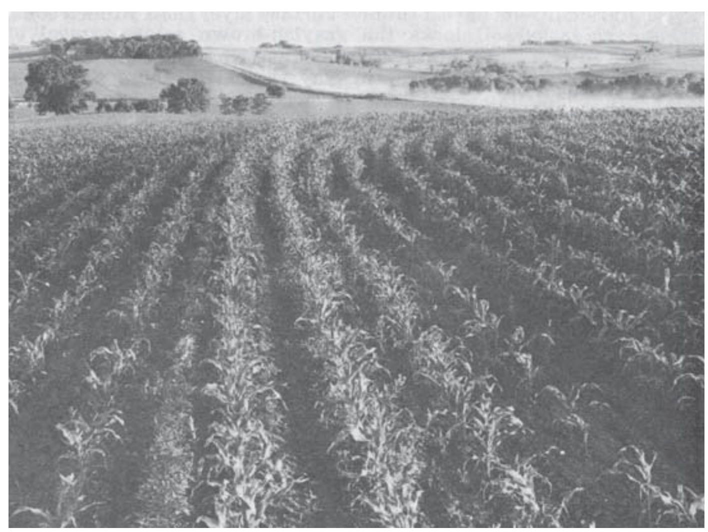

Figure 8.—**Corn on level terraces constructed in Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded, for control of erosion and to conserve moisture.**

be kept high, erosion controlled, and other good management used to maintain productivity. Growing meadow crops in the cropping system helps to improve tilth and increase productivity. Gullies have formed in some places. These must be shaped and seeded to grass for use as waterways for the safe removal of runoff water. Capability unit IIIe–3.

Marshall silty clay loam, 9 to 14 percent slopes, severely eroded (MhD3).—Many areas of this soil occupy the entire side of a slope, below less sloping Marshall soils, and extend downslope to upland drainageways. Some areas are upslope from Adair, Clarinda, and Shelby soils on glacial material. Individual areas generally are between 10 and 25 acres in size.

All but 3 inches or less of the original very dark grayish-brown surface layer of this soil has been removed through erosion as the result of past cropping practices. In many places the dark-brown subsoil is exposed. The subsoil is not so thick as that in less sloping Marshall soils. Depth to the silt loam parent material generally is within 40 inches. The content of organic matter in this soil is low. The surface soil is hard to work, puddles readily when wet, and becomes cloddy and hard when dry.

Included with this soil are about 20 acres of a soil that is on benches adjacent to stream valleys. These areas are on the sides of the benches below less sloping Marshall soils on the tops of the benches.

Much of this soil is used for row crops because many areas are surrounded by soils better suited to cultivated crops. Some areas are pastured. Sheet and gully erosion have reduced productivity.

If this soil is used for row crops, contour farming and terracing are needed. A cropping system that includes grasses and legumes helps to build up soil fertility and to reduce erosion. Any gullies in the areas need to be filled, smoothed, and planted to grasses for use as waterways. The sodded waterways also provide a crossing for farm machinery. Adding barnyard manure and fertilizer help to maintain productivity. Under good management, the response of hay and pasture crops is good. Capability unit IIIe–3.

Marshall silty clay loam, 14 to 18 percent slopes, moderately eroded (MhE2).—This soil occurs downslope from less sloping Marshall soils on ridgetops. Many of the areas occupy the entire side of a slope and grade downslope to upland drainageways and first bottoms. Some of the areas are upslope from Adair, Clarinda, and Shelby soils on glacial material. Individual areas generally are between 10 and 40 acres in size.

The surface layer of this soil is very dark grayish brown to very dark brown or dark brown and is 3 to 7 inches thick. In some places material from the subsoil has been mixed with the original surface layer by plowing. The subsoil is thinner than in less sloping Marshall soils. Depth to the silt loam parent material generally is not more than 36 inches. The content of organic matter is low in this soil. This soil is likely to puddle if worked when wet and becomes cloddy when dry. It is subject to serious sheet and gully erosion.

Included with this soil is about 200 acres of Marshall soils that have a very dark brown to very dark grayish-brown surface layer 7 to 14 inches thick.

This Marshall soil is not suited to intensive cultivation. A row crop can be grown occasionally, but it is better to keep the areas in hay or pasture most of the time. Areas that are cultivated generally adjoin soils better suited to cultivation.

If row crops are grown on this soil, terracing and farming on the contour are needed. Constructing terraces on less sloping soils upslope and farming these areas on the contour are ways to conserve moisture and to protect areas of this soil from further erosion. Gullies in the sides of slopes need to be filled and seeded to grass for use as waterways. The sodded waterways help to control runoff and also provide a crossing for farm machinery. The response of hay and pasture crops is fair if management is good. Capability unit IVe–1.

Marshall silty clay loam, 14 to 18 percent slopes, severely eroded (MhE3).—This soil is on side slopes. Many areas are narrow and are at the head of steep coves below gently sloping soils on ridgetops. Other areas occupy the entire side of the slope and in places extend downslope to Adair, Clarinda, and Shelby soils on glacial till or to soils in upland drainageways. Individual areas generally are between 10 and 20 acres in size.

All but 3 inches or less of the original surface layer of this soil has been washed away. The present surface layer is dark grayish brown. In most places the dark-brown subsoil is exposed. The content of organic matter is low. It is difficult to keep this soil in good tilth.

This soil is poorly suited to row crops, but some small areas are farmed along with larger areas of soils better suited to row crops. Row crops can be grown occasionally, but it is better to keep the areas in hay or pasture most of the time.

If row crops are grown on this soil, terracing and farming on the contour are needed. Farming the less sloping soils upslope on the contour and constructing terraces in these areas are ways to protect this soil from further sheet and gully erosion. Any gullies in the areas must be filled, shaped, and seeded to grass to provide waterways for removal of runoff. Because of the severe erosion, additions of manure and fertilizer are especially beneficial. Under good management, the response of hay and pasture crops is good. Capability unit IVe–1.

Marshall silty clay loam, benches, 0 to 2 percent slopes (MmA).—This soil occupies large areas along the East Nishnabotna River on high benches that have a cover of loess. In some places the areas are surrounded by Marshall silty clay loam, benches, 2 to 5 percent slopes. In other places this soil surrounds areas of Minden soils on benches. Several areas are more than 100 acres in size, but others range from 10 to 50 acres.

The surface layer of this soil is black to very dark brown and is as much as 20 inches thick. Depth to mottling generally is somewhat less than in more sloping Marshall soils. A few areas receive runoff from adjacent slopes and are somewhat wet for short periods.

Many areas of this soil are large enough to be farmed separately. Row crops can be grown frequently under good management. Growing an occasional meadow crop and plowing under crop residues are ways to maintain or improve tilth. Because this soil is nearly level, it is likely to be leached more deeply than other Marshall soils and need more lime. Capability unit I–1.

Marshall silty clay loam, benches, 2 to 5 percent slopes (MmB).—Most of this soil is adjacent to and on both sides of the East Nishnabotna River, which dissects the county from northeast to southwest. Some areas, however, are scattered along other streams in the Marshall association on high benches that parallel the streams. The areas extend downslope to soils of alluvial flood plains. They have a cover of loess that ranges from 15 to 20 feet in thickness. This soil is associated with nearly level Marshall soils and with soils of the Bremer, Judson, Minden, and Nevin series. Individual areas range from 10 to 60 acres in size.

In most places the surface layer of this soil is black to very dark brown and is about 10 to 16 inches thick. In some cultivated areas, however, the surface layer is very dark brown and is 7 to 12 inches thick. In a few acres only 3 to 7 inches of the original surface layer remains. The content of organic matter in this soil generally is high. Tilth is good.

Included with this soil are some small areas that have slopes of less than 2 percent.

This Marshall soil generally is used and managed the same as Marshall silty clay loam, 2 to 5 percent slopes. Some areas of this soil are large enough to be farmed separately, but generally the areas are cropped along with surrounding soils.

If this soil is farmed on the contour, it can be used frequently for row crops. In some places the relief hinders laying out of terraces, but contour tillage generally is feasible. If fertility is kept high, crops respond well in areas used intensively for crops. Capability unit IIe-1.

Marshall silty clay loam, benches, 5 to 9 percent slopes, moderately eroded (MmC2).—Most of this soil is parallel to the East Nishnabotna River on high stream benches that have a cover of loess. Some small areas are in stream valleys in other parts of the Marshall association on similar benches. The areas generally are narrow and are between higher lying soils on the benches and lower lying soils on first bottoms. They generally are between 10 and 30 acres in size and are scattered along the streams.

The surface layer of this soil is very dark grayish-brown or very dark brown silty clay loam 3 to 7 inches thick. In a few places dark-brown material from the subsoil is mixed into the surface layer by plowing.

Included with this soil are fairly large areas of slightly eroded soils that have a black to very dark brown surface layer 7 to 14 inches thick.

This Marshall soil generally is cropped and managed the same as Marshall soils in the uplands on 5 to 9 percent slopes. Most areas are farmed along with surrounding soils. Practices that prevent further erosion are needed, but terracing generally is not feasible because the slope pattern is too complex.

This soil is well suited to row crops. It ought to be farmed on the contour, and cropping systems need to be used that control soil losses. Growing meadow crops in the cropping system is a way to improve soil tilth and increase the content of organic matter. Capability unit IIIe-1.

Minden Series

The Minden series consists of nearly level, deep, dark-colored soils that are somewhat poorly drained. These soils formed under prairie grasses in loess. They are mainly on nearly flat benches that border stream valleys, but some areas are on broad ridgetops in the uplands within areas of the Marshall association. The areas are mostly on benches along the East Nishnabotna River or on upland flats in Pleasant Township. Minden soils are associated with nearly level Marshall soils and with Corley soils in shallow depressions.

The surface layer is black or very dark gray, friable light silty clay loam that has fine granular and very fine subangular blocky structure. It is about 20 inches thick. The subsoil is dark grayish-brown, friable silty clay loam. It has many yellowish-brown mottles, has subangular blocky structure, and extends to a depth of about 48 inches. The substratum is olive, friable, massive silt loam that has many yellowish-brown mottles.

Minden soils have high available moisture capacity and high content of organic matter. Permeability of the subsoil is moderate to moderately slow. These soils are medium to low in available nitrogen, medium in phosphorus, and high to medium in potassium, and they are slightly acid to medium acid.

Representative profile of Minden silty clay loam, benches, in a nearly level area (240 feet west and 380 feet north of the southeast corner of the SW¼SE¼ sec. 31, T. 75 N., R. 37 W.):

Ap—0 to 7 inches, black (10YR 2/1) or very dark gray (10YR 3/1) light silty clay loam; moderate, fine, granular structure; friable; slightly acid; clear boundary.

A12—7 to 15 inches, black (10YR 2/1) light silty clay loam; weak, very fine, subangular blocky structure that breaks to moderate, fine and medium, granular; friable; medium acid; clear boundary.

A13—15 to 22 inches, black (10YR 2/1) to very dark gray (10YR 3/1) light silty clay loam that is very dark gray (10YR 3/1) when kneaded; weak, very fine, subangular blocky structure that breaks to moderate, fine and medium, granular; friable; medium acid; gradual boundary.

B1—22 to 29 inches, dark grayish-brown (10YR 4/2) silty clay loam that has very dark grayish-brown (10YR 3/2) ped exteriors; a few, fine, faint mottles of yellowish brown (10YR 5/6); weak, fine, subangular blocky structure; friable; medium acid; gradual boundary.

B2—29 to 35 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; many, fine, distinct mottles of yellowish brown (10YR 5/6); moderate to strong, fine, subangular blocky structure; friable to firm; concretions of iron and manganese; medium acid; gradual boundary.

B3—35 to 46 inches, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) light silty clay loam; many, medium, distinct mottles of yellowish brown (10YR 5/6) and a few fine mottles of olive gray (5Y 5/2); weak, coarse, subangular blocky structure; friable; many fine pinholes; concretions of iron and manganese; medium acid; gradual boundary.

C1—46 to 60 inches, olive (5Y 5/3) silt loam; many, medium, distinct mottles of yellowish brown (10YR 5/6); massive; friable; medium acid.

The surface layer is black or very dark gray in color; heavy silt loam or light silty clay loam in texture; and 18 to 22 inches in thickness. The subsoil typically is dark grayish-brown silty clay loam. It is 30 to 35 percent clay. Mottles of yellowish brown and strong brown are in the upper part of the subsoil, and they increase in size and abundance with depth. In many places the lower part of the subsoil and the underlying material are olive to gray in color and have yellowish-brown and strong-brown mottles.

Minden soils have a thicker surface layer than Marshall soils and have a grayish-brown subsoil that is more mottled than the one in those soils. They lack the light-colored subsurface layer typical of Corley soils, and their subsoil is less gray. Minden soils are more acid than Nevin soils, and their subsoil is not so firm nor so clayey.

Minden silty clay loam, benches (0 to 2 percent slopes) (Mn).—This is the only Minden soil mapped in the county. Individual areas range from about 5 to 30 acres in size and are along the East Nishnabotna River. The profile of this soil is like the one described as representative for the series.

Included with this soil are some areas of Corley soils. These areas are small and are shown on the detailed soil map by a spot symbol.

This Minden soil puddles if worked when wet and becomes cloddy and hard when dry. Some areas are in shallow depressions, and water is likely to pond in these areas. Other areas receive runoff occasionally from adjacent higher areas or as the result of overflow from small tributary streams. Most areas are farmed without artificial drainage. Tile drains work well in this soil, however, and surface drains are beneficial in some places.

Row crops can be grown frequently on this soil. Under good management, including plowing under crop residues, tilth can be maintained and crops respond well. Capability unit I-1.

Nevin Series

The Nevin soils are nearly level, dark colored, and somewhat poorly drained. These soils formed in silty alluvium under prairie grasses. They are on low stream benches or second bottoms. Nevin soils occupy broad areas that slope gradually toward alluvial flood plains. Most of the areas are in the valley of the East Nishnabotna River, which dissects the county. Small areas, however, occur at the lower end of Indian and Turkey Creeks. Nevin soils are associated with the Bremer, Corley, Judson, and Wabash soils. In many places they are surrounded by Marshall and Minden soils, which occupy higher areas on the rim of these soils.

The surface layer is black or very dark gray friable light silty clay loam that generally has fine granular structure and is about 24 inches thick. The subsoil extends to a depth of about 60 inches and has subangular blocky structure. It is very dark grayish-brown, friable light silty clay loam in the upper part. The middle part is very dark grayish-brown and dark grayish-brown, friable to firm heavy silty clay loam that has olive-brown and yellowish-brown mottles. The lower part is olive, friable to firm silty clay loam and has olive-gray and yellowish-brown mottles. Dark grayish-brown, coarse silt and fine sand that is highly mottled with gray occur at a depth between 12 and 14 feet.

These soils have high available moisture capacity. Permeability is moderate to moderately slow. Nevin soils are medium to low in available nitrogen, are medium to high in phosphorus, and generally are low to medium in available potassium. They typically are slightly acid.

Representative profile of Nevin silty clay loam on a slope of about 1 percent (50 feet east and 110 feet north of the southwest corner of the SE¼ sec. 5, T. 74 N., R. 37 W.):

Ap—0 to 4 inches, black (10YR 2/1) or very dark gray (10YR 3/1) light silty clay loam that is very dark brown (10YR 2/2) when crushed; cloddy, but breaks to weak, very fine, granular structure; friable; many pores and worm casts; neutral; abrupt boundary.

A12—4 to 12 inches, black (10YR 2/1) or very dark gray (10YR 3/1) light silty clay loam; cloddy, but breaks to weak, fine, granular structure; friable; many pores and worm casts; neutral; abrupt boundary.

A13—12 to 19 inches, black (10YR 2/1) light silty clay loam; weak, fine, granular structure; friable; many pores, fine roots, and worm casts; neutral; gradual boundary.

A14—19 to 25 inches, black (10YR 2/1) light silty clay loam; a few, fine, faint mottles of dark brown (10YR 3/3); weak, fine, subangular blocky structure that breaks to weak, fine, granular; friable; many fine pores and worm casts; slightly acid; gradual boundary.

B1—25 to 32 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, very dark gray (10YR 3/1) ped exteriors; a few, fine, faint mottles of dark grayish brown (2.5Y 4/2) and a few, fine, faint mottles of dark brown (10YR 3/3); weak, very fine, subangular blocky structure; friable; many fine pores and fine roots; slightly acid; clear boundary.

B21—32 to 43 inches, dark grayish-brown (2.5Y 4/2) heavy silty clay loam; many, fine, distinct mottles of olive gray (5Y 5/2) and a few, fine, distinct mottles of olive brown (2.5Y 4/4); moderate, fine, subangular blocky structure; friable to firm; many very fine pores and a few fine roots; neutral; gradual boundary.

B22t—43 to 51 inches, dark grayish-brown (2.5Y 4/2) heavy silty clay loam; many, large, prominent mottles of olive brown (2.5Y 4/4); many, medium, distinct mottles of olive gray (5Y 5/2); and a few, fine, distinct mottles of yellowish brown (10YR 5/6); moderate to strong, very fine, subangular blocky structure; friable to firm; a few very fine pores; some very fine roots; a few worm casts; a few small oxides; a few, thin, discontinuous clay films on peds; neutral; clear boundary.

B3—51 to 60 inches, olive-brown (2.5Y 4/4) medium silty clay loam; many, coarse, prominent mottles of olive gray (5Y 5/2) and many, medium, distinct mottles of yellowish brown (10YR 5/6); very weak, medium, subangular blocky structure to massive; friable to firm; many very fine pores; a few fine oxides; neutral.

The surface layer is black or very dark gray light silty clay loam and is about 2 feet thick. The subsoil is very dark grayish-brown to grayish-brown silty clay loam and has a clay content of 32 to 38 percent. It commonly is mottled with yellowish brown, grayish brown, olive gray, and olive brown. The mottles increase in contrast and size with depth.

Nevin soils are more clayey and firmer in the subsoil and underlying material than Minden soils. They also are less acid. They are less clayey than Bremer soils, and are not so poorly drained, and their subsoil is less gray.

Nevin silty clay loam (0 to 2 percent slopes) (Ne).—This is the only Nevin soil mapped in the county. Individual areas are as much as 160 acres in size. The profile of this soil is like the one described as representative for the series.

Included with this soil are some small areas of a soil that has a surface layer of very dark gray to very dark brown silt loam and a subsoil of very dark gray silty clay loam. When dry, the subsoil is mottled with dark brown, dark yellowish brown, and brown. Also, when dry, light-gray, distinct silt coatings occur throughout the profile. These included areas formerly were under timber.

Many areas of this Nevin soil are large enough that an entire field consists of it. Row crops can be grown frequently, and the crops respond well if soil tilth and fertility are maintained and if management otherwise is good.

Little water runs off this soil. The areas generally are farmed without artificial drainage, but tile drains work well in this soil if outlets are available. Diversion terraces placed at the base of adjacent slopes help to control runoff and reduce wetness. Capability unit I-1.

284-563 O—68——3

Nodaway Series

In the Nodaway series are nearly level, stratified, moderately dark colored and light-colored soils that are moderately well drained to somewhat poorly drained. These soils formed in recent silty alluvium along most of the major streams and their tributaries. They are adjacent to the stream channels and generally occupy parallel areas along both sides of the major streams. Nodaway soils are the most extensive of any soils on bottom lands in the county. They are associated with the Colo, Kennebec, and Zook soils.

Nodaway soils consist of very dark grayish-brown, stratified silt loam that includes some strata of silt and very fine sand. A black, old, buried soil of silty clay loam, or of coarser texture, occurs in places at a depth below 30 inches.

These soils have high available moisture capacity. The content of organic matter is moderately low. Permeability of the underlying layer is moderate, and dark-brown mottles occur in areas that are flooded frequently. Some areas are cut by old meandering streams and by drainage channels filled with water, and these cannot be crossed with farm machinery. Nodaway soils are low in available nitrogen, medium in available phosphorus, and low to medium in available potassium. They generally are neutral to slightly acid.

Representative profile of Nodaway silt loam on a nearly level bottom land near Turkey Creek (400 feet north and 40 feet east of the center of the road, from the southwest corner of the SW¼NE¼ sec. 31, T. 77 N., R. 34 W.):

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine and very fine, subangular blocky structure; friable; slightly acid; clear boundary.

C1—5 to 14 inches, stratified, very dark grayish-brown (10YR 3/2) silt loam and thin grayish-brown (2.5Y 5/2) silt lenses and some very fine sand lenses; moderate, thin, platy structure that breaks to weak, fine, granular; friable; dark-brown (7.5YR 3/2) root stainings; slightly acid; gradual boundary.

C2—14 to 32 inches, stratified, very dark grayish-brown (10YR 3/2) silt loam and thin grayish-brown (2.5Y 5/2) silt lenses and some very fine sand lenses; weak, thin, platy structure that breaks to weak, fine, granular; friable; some brown (10YR 5/3) silt coatings on horizontal cleavage faces; slightly acid; clear boundary.

C3—32 to 39 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, thin, platy structure; friable; some mixing of dark-brown to brown (10YR 4/3) material because of biological activity; a few dark-brown (7.5YR 3/2) root stains on horizontal cleavages; slightly acid; abrupt boundary.

IIA1b—39 to 50 inches, black (10YR 2/1) silt loam; weak, very fine, subangular and weak, fine, granular structure; friable; medium acid.

In cultivated areas the plow layer commonly is very dark grayish brown, but it ranges from very dark gray to dark grayish brown. The color of the stratified layers that make up the soil matrix ranges from very dark gray to dark yellowish brown. Strong-brown to dark grayish-brown mottles are common. Mottling generally is more distinct and more contrasting in channeled areas. Nodaway soils have variable but distinct, thin, stratified layers of silt and some sand in the profile. The texture generally is silt loam. A dark-colored, buried soil of silty clay loam, or of coarser texture, occurs at a depth below 30 inches in some places.

Nodaway soils are lighter colored than Colo and Kennebec soils, and unlike those soils, are distinctly stratified. They are not so fine textured as Colo soils.

Nodaway silt loam (0 to 2 percent slopes) (No).—This soil is on first bottoms. It is the most extensive Nodaway soil in the county, and it occupies a larger acreage than any of the other soils on bottom lands. Individual areas are as much as 200 acres in size.

The profile of this soil is like the one described as representative for the series. Many areas of this soil formerly were cut by old shallow channels, which have been filled and are now farmed. The straightening of channels of nearby rivers and creeks and the clearing of undergrowth and trees have made many areas of this soil suitable for crops. This soil is subject to overflow, and protection from overflow is needed in some places. The areas seldom remain too wet, however, for crops. Tilth generally is fairly good, though the content of organic matter is low. This soil warms up earlier in spring than the darker colored soils on bottom lands. Except after damaging floods, crops on this soil respond well.

This soil is well suited to cultivated crops, and row crops can be grown frequently. The areas generally are farmed along with the associated Colo, Kennebec, and Wabash soils. Some areas, however, are large enough that they are farmed separately. Capability unit I–2.

Nodaway silt loam, channeled (0 to 2 percent slopes) (Nw).—This soil occurs along many of the streams in the county. The size of individual areas ranges from 10 to 75 acres.

Areas of this soil are cut by old channels of meandering streams. In many places these oxbow channels are filled with water. In other places the oxbows are filled with wet, sandy and silty sediments or have a cover of weedy and scrubby undergrowth.

In many areas of this soil, the water table is high during wet seasons. The subsoil generally is mottled with dark-brown iron stains. The areas are flooded frequently and receive additional deposits of silt, which are laid down by slow-moving floodwaters.

Areas of this soil generally are pastured or left idle. Many of the areas would be suitable for crops if the vegetation were cleared, old channels filled, and surface drainage provided. Protection from overflow is needed if the areas are cropped continuously. Capability unit Vw–1.

Olmitz Series

The Olmitz series consists of dark-colored soils that are moderately well drained. These soils formed under prairie grasses in alluvium washed from adjoining, higher lying soils in the uplands. They occupy small areas scattered throughout the county. In many places the areas are narrow and are in concave areas on foot slopes above soils on stream benches and bottom lands. Other areas are on gently sloping alluvial fans at the mouths of intermittent drainageways. Slopes range from 2 to 5 percent. Olmitz soils are associated with Gara, Ladoga, Marshall, Sharpsburg, and Shelby soils, which are in the uplands. In many places they adjoin Colo, Judson, and Wabash soils, which are downslope on alluvium.

The surface layer is black to very dark brown, friable heavy loam that has fine subangular blocky structure. Just below is a layer of very dark grayish-brown, friable light clay loam that is about 10 inches thick. This transitional layer is lacking in many places. The subsoil is very dark grayish-brown and dark-brown to brown, friable light clay loam that has subangular blocky structure. It extends to a depth of more than 48 inches. The parent material is local alluvium washed over a long period of time from soils on loess and on glacial till.

The content of organic matter in these soils is medium. Permeability of the subsoil is moderate to moderately slow. These soils are subject to gully erosion if runoff is not controlled. Some areas are wet in rainy seasons because of seepage from adjacent soils. Olmitz soils are low in nitrogen and phosphorus, medium in available potassium, and are slightly acid or medium acid.

Representative profile of Olmitz loam on a slope of about 3 percent (725 feet east and 300 feet north of the southwest corner of the NW¼SW¼ sec. 33, T. 74 N., R. 34 W.):

A11—0 to 9 inches, black (10YR 2/1) heavy loam; weak, thin, platy structure that breaks to weak, fine, granular; friable; many fine roots; medium acid; clear boundary.

A12—9 to 16 inches, black (10YR 2/1) heavy loam that is very dark brown (10YR 2/2) when kneaded; moderate, fine, subangular blocky structure that breaks to weak, fine, granular; friable; a few fine pores; a few fine roots; medium acid; gradual boundary.

A13—16 to 23 inches, very dark brown (10YR 2/2) heavy loam; moderate, fine, subangular blocky structure; friable; a few fine pores; a few very fine roots; medium acid; gradual boundary.

AB—23 to 33 inches, very dark grayish-brown (10YR 3/2) light clay loam with very dark gray (10YR 3/1) ped exteriors; moderate, fine, subangular blocky structure; friable; medium acid; gradual boundary.

B1—33 to 40 inches, very dark grayish-brown (10YR (3/2) and dark-brown to brown (10YR 4/3) light clay loam that is dark brown (10YR 3/3) when kneaded; moderate, fine and medium, subangular blocky structure; friable; medium acid; gradual boundary.

B2—40 to 54 inches, very dark grayish-brown (10YR 3/2), and dark-brown to brown (10YR 4/3) light clay loam that is dark brown (10YR 3/3) when kneaded; common, medium, distinct mottles of yellowish red (5YR 4/6); moderate, medium, subangular blocky structure; friable to firm; a few small pebbles; medium acid.

Olmitz soils are black to very dark brown to a depth between 20 and 30 inches. Some areas have a few inches of very dark grayish-brown overwash on them. The surface layer is loam to light clay loam in texture. The subsoil generally is very dark grayish brown in the upper part and grades to dark brown or brown in the lower part. In texture the subsoil generally is clay loam, and the clay content is 28 to 34 percent. In most places dark-brown to yellowish-red mottles are in the lower part of the subsoil or substratum. Small pebbles occur in the profile in some places, though large stones are lacking.

These soils have a higher sand content than Judson and Colo soils. They are not so dark colored as the Colo soils at a depth between 30 and 40 inches.

Olmitz loam, 2 to 5 percent slopes (OmB).—This is the only Olmitz soil mapped in the county. Its profile is like the one described as representative for the series. This soil generally is in good tilth.

Included with this soil are some areas that have 6 to 16 inches of very dark grayish-brown sediment on the surface. In most of these areas, the surface layer contains coarse sand and small pebbles and is loam to light clay loam in texture. The areas commonly are along drainageways, where material washed into the drainageways from nearby soils on glacial till was redeposited by overflow.

This Olmitz soil generally is used for the same crops as adjoining soils, but many areas are used for permanent pasture. The areas seldom are cropped individually, because they generally are less than 10 acres in size.

Areas of this soil on alluvial fans receive runoff and overwash from the uplands. Some places are gullied. Constructing terraces upslope is a way to prevent runoff. The terraces also reduce the hazard of sheet erosion and keep gullies from forming. This soil is somewhat erodible, and all tillage ought to be done on the contour. If tillage is done on the contour, row crops can be grown frequently. Capability unit IIe–2.

Sandstone Rock Land

Sandstone rock land (Sa) consists of material weathered from sandstone. The areas are in the uplands under a cover of various kinds of grasses and trees. They are strongly sloping and occupy irregular, convex lower side slopes near Cold Springs State Park. Individual areas range from 5 to 15 acres in size. This land type generally is downslope from Ladoga and Marshall soils and just above drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes.

Areas of this land type generally have about 8 inches of dark-brown to brown sandy loam on the surface and are underlain by sand. Many areas, however, have fragments of sandstone on the surface and throughout the profile and are underlain by sandstone bedrock.

Sandstone rock land generally is in permanent vegetation. Some areas are gullied. In other areas bedrock of sandstone or shale crops out.

Pasture, and perhaps wildlife habitats, are suitable uses for this land type. The gullies, rock fragments, and outcrops of bedrock generally make it impractical to use tillage implements on the areas. Farming on the contour in soils upslope and terracing these areas are ways of controlling runoff and reducing erosion and gullying. Capability unit VIIe–1.

Sharpsburg Series

In the Sharpsburg series are deep, dark-colored, well drained to moderately well drained soils. These soils formed under prairie grasses in loess. Slopes range from 0 to 25 percent, but they are 2 to 14 percent in most places. The areas occupy positions ranging from nearly level ridgetops to steep side slopes and are in the eastern one-third of the county.

Sharpsburg soils are associated with all soils of the uplands in the eastern one-third of the county, including those of the Adair, Clarinda, Gara, Ladoga, and Shelby series. They generally are upslope from Adair, Clarinda, and Shelby soils, but in some areas they occupy the entire side slope.

The surface layer is friable silty clay loam that has very fine and fine subangular blocky structure and is about 12 inches thick. It is black to very dark brown in the upper part and very dark brown and very dark grayish brown in the lower part. The subsoil extends to a depth of 4 feet or more. It is mainly dark-brown to brown, friable to firm silty clay loam that is mottled with strong brown, yellowish brown, and gray. Structure is subangular blocky. In many places the subsoil is highly mottled in the lower part. The underlying loess ranges from 10 to 20 feet in thickness and is underlain by glacial till of Kansan or Nebraskan time.

These soils have high available moisture capacity. Except in severely eroded areas, the content of organic matter is high to medium. Permeability is moderate to moderately slow. Sharpsburg soils generally are low to medium in available nitrogen and phosphorus and medium to high in potassium. They are medium acid in most places. Sloping areas are subject to erosion and require protection if cultivated crops are grown.

Representative profile of Sharpsburg silty clay loam on a high, stable interfluve on a slope of about 3 percent that faces northeast (240 feet north and 185 feet west of center of the road, which is the southeast corner of sec. 16, T. 74 N., R. 34 W.):

Ap—0 to 8 inches, black (10YR 2/1) to very dark brown (10YR 2/2) light silty clay loam that is very dark brown (10YR 2/2) when crushed; cloddy, but breaks to moderate, very fine, subangular blocky structure; friable to firm; at a depth between 6 and 8 inches, the horizon is very compact and firm and breaks to medium angular blocky structure; medium acid; abrupt, smooth boundary.

A12—8 to 13 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) silty clay loam that is very dark grayish brown (10YR 3/2) when crushed; a few fine spots of dark brown to brown (10YR 4/3); weak, fine, subangular blocky structure that breaks to moderate, very fine and fine, granular; friable; many very fine and a few fine tubular pores; medium acid; clear, smooth boundary.

B1—13 to 18 inches, very dark grayish-brown (10YR 3/2) and dark-brown to brown (10YR 4/3) medium silty clay loam; the very dark brown and very dark grayish-brown peds crush to very dark grayish brown (10YR 3/2), but the dark-brown to brown peds are the same color when crushed; moderate, very fine, subangular blocky structure; very dark brown (10YR 2/2) coats; friable; many very fine and a few fine tubular pores; medium acid; clear, smooth boundary.

B21—18 to 21 inches, dark-brown to brown (10YR 4/3) medium silty clay loam; a few ped coatings and old root fills of black (10YR 2/1) and very dark brown (10YR 2/2); moderate, fine, subangular blocky structure; friable to firm; many, very fine and a few fine tubular pores; a few, fine, very dark brown, soft concretions of an oxide; slightly acid; gradual, smooth boundary.

B22t—21 to 27 inches, dark-brown to brown (10YR 4/3) medium silty clay loam; common, fine, distinct mottles of strong brown (7.5YR 5/6) and yellowish brown (10YR 5/6); moderate, medium, subangular blocky structure; friable to firm; many, very fine and a few fine tubular pores; many peds have thin, patchy clay films of dark grayish brown (10YR 4/2); common, fine, very dark brown, soft concretions of an oxide; slightly acid; gradual, smooth boundary.

B23t—27 to 34 inches, dark-brown (10YR 4/3) to brown (10YR 5/3) silty clay loam; many, fine, distinct mottles of gray (5Y 6/1) and light olive gray (5Y 6/2); common, fine, distinct mottles of strong brown (7.5YR 5/6) and a few, fine, faint mottles of yellowish brown (10YR 5/6); weak, medium, subangular blocky structure; friable to firm; many, very fine and a few fine tubular pores; many peds have thin patchy clay films of dark grayish brown (10YR 4/2); common, fine, very dark brown, soft concretions of an oxide; slightly acid; gradual, smooth boundary.

B3t—34 to 42 inches, dark-brown (10YR 4/3) to brown (10YR 5/3) light silty clay loam; many, fine, distinct mottles of strong brown (7.5YR 5/6 and 5/8); many, fine, distinct mottles of gray (5Y 6/1); a few, fine, faint mottles of yellowish brown (10YR 5/6) and a few, fine, distinct mottles of light olive gray (5Y 6/2); weak, medium, subangular blocky structure; friable; many, very fine and a few fine tubular pores; a few peds have thin patchy clay films of dark grayish brown (10YR 4/2); a few, fine, very dark brown, soft concretions of an oxide; slightly acid; gradual, smooth boundary.

B32—42 to 50 inches, mottled gray (5Y 6/1), light olive-gray (5Y 6/2), strong-brown (7.5YR 5/6), and yellowish-brown (10YR 5/4 and 5/6) light silty clay loam; weak, coarse, subangular blocky structure; friable; many, very fine and a few fine tubular pores; a few, fine, very dark brown, soft concretions of an oxide; slightly acid.

The surface layer generally is black to very dark brown, but in many places it grades to very dark grayish brown in the lower part. It is 10 to 16 inches thick in areas not eroded. The subsoil typically is silty clay loam in texture and is 36 to 40 percent clay in the finest textured part. It generally is dark brown to brown and has some mottling in the lower part. The underlying silt loam material, which occurs at a depth below 48 inches, ranges from yellowish brown to olive gray and is mottled with strong brown, yellowish brown, or grayish brown.

Sharpsburg soils have a higher content of clay than Marshall soils, and their subsoil has a more distinct increase in clay content. Also, mottles generally occur slightly higher in the soil profile than in Marshall soils. Sharpsburg soils lack the light-colored subsurface horizon and distinct grainy coatings in the subsoil typical of Ladoga soils and are less acid.

Sharpsburg silty clay loam, 0 to 2 percent slopes (SbA).—This soil is on broad ridgetops and generally is surrounded by Sharpsburg silty clay loam, 2 to 5 percent slopes. Individual areas usually range between 10 and 60 acres in size. The surface layer is black to very dark brown and in many places is as much as 18 inches thick.

Most areas of this soil are cultivated. This soil generally is farmed along with surrounding soils. It has few limitations for growing row crops. Returning crop residues to the soil helps to keep this soil in good tilth. Some areas are more acid than other Sharpsburg soils and may require larger amounts of lime. Capability unit I–1.

Sharpsburg silty clay loam, 2 to 5 percent slopes (SbB).—Most of this soil is on ridgetops in the Sharpsburg association, but a small acreage is on high benches. The areas are downslope from Sharpsburg silty clay loam, 0 to 2 percent slopes, and generally are upslope from more sloping Sharpsburg soils. Individual areas are as much as 80 acres in size, and on some ridgetops the areas extend for a mile or more.

The profile of this soil is like the one described as representative for the series.

Included with this soil is a small acreage of a soil that has a surface layer that is very dark brown or very dark grayish brown and is 3 to 7 inches thick. Also included are some areas that have slopes of less than 2 percent. These included soils are too small to be mapped separately.

Most areas of this Sharpsburg soil are used for crops, and some areas are large enough that they are farmed separately. Only a few areas are in pasture.

Because this soil is subject to erosion, terracing or farming on the contour is needed if row crops are grown. Row crops can be grown frequently if erosion is controlled, fertility is kept high, and management is otherwise good. Capability unit IIe–1.

Sharpsburg silty clay loam, 5 to 9 percent slopes (SbC).—This soil is on many of the more narrow divides in the county, downslope from nearly level soils on ridgetops. Many of the areas are narrow and are upslope from steeper Sharpsburg soils or from Adair, Clarinda, and Shelby soils. In some places this soil occupies the entire side of a slope and extends downslope to upland drainageways. Individual areas are as much as 60 acres in size, and some extend for a mile or more along the crests of the divides.

The surface layer of this soil is black to very dark brown. It is 8 to 12 inches thick. This soil is easy to till. The hazard of erosion is severe if the areas are not protected.

If this soil is cultivated, it generally is farmed along with gently sloping Sharpsburg soils upslope. Some areas are in permanent pasture because they are associated with soils poorly suited to cultivation. Contour farming and terracing are needed for protection from erosion. Grass waterways provide safe removal of runoff water and prevent gullying. Capability unit IIIe-1.

Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded (SbC2).—This soil occupies positions similar to those occupied by Sharpsburg silty clay loam, 5 to 9 percent slopes, and is associated with the same soils. It is mainly in the southeastern part of the county, and individual areas are as much as 70 or 80 acres in size (fig. 9).

This is the most extensive Sharpsburg soil in the county. The surface layer is very dark grayish brown and is 3 to 7 inches thick. In most places dark-brown material formerly in the subsoil has been mixed with the remaining original surface soil by plowing. This soil is not so productive as less sloping Sharpsburg soils that are not eroded. Generally the content of organic matter is moderately low and tilth is fair. If this soil is worked when wet, the surface layer becomes hard and cloddy as it dries. Because this soil has been used for clean-tilled crops, the areas are sheet eroded and some areas are gullied. In places the fertility and the capacity of the soil to absorb moisture have been reduced.

Included with this soil are some severely eroded areas, where only about 3 inches of the original very dark grayish-brown surface layer remains and the dark-brown subsoil is exposed in many places. These areas are shown on the detailed soil map by the spot symbol for severe sheet erosion.

This Sharpsburg soil generally is farmed along with surrounding Sharpsburg soils, though some areas are farmed separately. Some other areas are in permanent pasture, particularly those areas on side slopes that adjoin steeper Adair or Shelby soils.

If this soil is protected from severe erosion by farming on the contour and by terracing, it is moderately well suited to cultivated crops. Any gullies in the areas need to be filled, shaped, and seeded to grass for use as waterways. Erosion can be reduced and tilth improved if a cropping system is used that includes meadow consisting of grasses and legumes. Capability unit IIIe-1.

Figure 9.—**Typical area of Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded. The hay is being windrowed.**

Sharpsburg silty clay loam, 9 to 14 percent slopes (SbD).—In many places this soil occupies narrow areas between higher lying, less sloping Sharpsburg soils and lower lying soils on glacial material. In some places this soil occupies the entire side of a slope and extends downslope to soils in upland drainageways or to soils on first bottoms. Individual areas are as much as 50 acres in size.

The surface layer generally is black to very dark brown in color and about 8 to 10 inches in thickness. On the average the surface layer is somewhat thinner than that of the profile described as representative for the series. Also, the subsoil is thinner and parent material generally is within 48 inches of the surface. This soil is in good tilth. The content of organic matter is fairly high.

Many areas of this soil are in permanent pasture because they are closely associated with soils not suited to row crops. This soil is suited to cultivation if soil losses are held to allowable limits. It also is well suited to hay or pasture.

If row crops are grown on this soil, contour farming and terracing are needed for control of erosion. Using a cropping system that includes grasses and legumes is a way to maintain tilth, improve the capacity to absorb moisture, and control erosion. Capability unit IIIe-3.

Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded (SbD2).—This soil is just below less sloping Sharpsburg soils. It generally occupies narrow areas around side slopes upslope from the Adair, Clarinda, and Shelby soils. Many other areas occupy the entire side of a slope and extend downslope to soils in drainageways and on first bottoms. Individual areas range from 10 to 100 acres in size.

The surface layer is very dark grayish-brown silty clay loam that is 3 to 7 inches thick. In places dark-brown subsoil has been mixed with the remaining surface soil by plowing. In many places near the upper ends of drainageways and the shoulders of slopes, the subsoil is exposed. Gullies are common in some areas. The content of organic matter is low in many places. In some places the soil is hard and cloddy when dry.

Many areas of this soil are used the same as adjoining soils, but some areas are farmed separately. Because of past intensive cropping and lack of erosion control, this soil is moderately eroded. Row crops can be grown part of the time, but the hazard of further erosion is severe if this soil is cultivated and not protected. Hay and pasture crops on this soil respond well.

Farming on the contour and terracing are ways to protect this soil from further erosion. Gullies in the areas need to be filled, shaped, and seeded to grass for use for hay and pasture crops. The grassy areas also provide a crossing for farm machinery. Growing grasses and legumes in the cropping system is a way to improve the tilth of this soil. This practice also increases the supply of organic matter and helps to control erosion. Capability unit IIIe-3.

Sharpsburg silty clay loam, 9 to 14 percent slopes, severely eroded (SbD3).—This soil occupies fairly narrow areas between higher lying, less sloping Sharpsburg soils and lower lying Adair, Clarinda, and Shelby soils. In places the soil occupies the entire side of a slope and extends downslope to upland drainageways occupied by Judson-Colo complex, 2 to 5 percent slopes. Individual areas generally are between 10 and 40 acres in size.

In places the surface layer of this soil is dark grayish brown in color and is only 3 inches thick. The dark-brown subsoil is not so thick as in less sloping Sharpsburg soils, and it is exposed in most places. Much of the original surface soil has been washed away as the result of past intensive use for clean-tilled crops. Fertility therefore is lowered and the ability of the soil to absorb moisture is reduced. The content of organic matter is low. If worked when wet, this soil puddles and becomes cloddy when dry.

Low fertility and steep slopes make this soil poorly suited to row crops, though a year of row crops can be grown when establishing pasture or a stand of hay. Many areas are farmed with surrounding soils better suited to cultivation.

Good management is needed to prevent further severe sheet erosion and to keep other gullies from forming. Terracing and farming on the contour are ways to prevent further erosion. The gullies need to be filled, smoothed, and seeded to grass for use as waterways. Forage crops on this soil respond under good management that includes adding barnyard manure and applying fertilizer. Capability unit IVe-1.

Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded (SbE2).—This soil generally is downslope from less sloping Sharpsburg soils and upslope from soils on glacial till. In some places the soil occupies narrow areas around the entire side of a slope.

The surface layer of this soil is very dark grayish brown to dark brown and is 3 to 7 inches thick. The subsoil extends to a depth of about 42 inches. It is not so fine textured as that in less sloping Sharpsburg soils. This soil is subject to severe sheet and gully erosion from runoff. It generally has low content of organic matter.

Included with this soil, and making up about one-fourth of the area, is a soil that has 7 to 14 inches of very dark brown surface soil remaining. Also included are some areas in which only 3 inches of very dark grayish-brown surface layer remains or dark-brown subsoil is exposed. Some included areas have slopes of as much as 25 percent.

This Sharpsburg soil is poorly suited to cultivated crops, but many small areas are farmed with other soils better suited to row crops. It is well suited to hay and pasture. A row crop can be grown when establishing pasture or a stand of hay.

If this soil is used for row crops, all cultivation must be on the contour. Less sloping areas above this soil need to be terraced and farmed on the contour to protect this soil from further sheet and gully erosion. Gullies in the sides of hills need to be filled, smoothed, and seeded to grass for use as waterways. Forage crops on this soil respond fairly well under good management, which includes adding fertilizer. Capability unit IVe-1.

Sharpsburg silty clay loam, 14 to 18 percent slopes, severely eroded (SbE3).—This soil is downslope from less sloping Sharpsburg soils and generally is upslope from Shelby soils. Some areas occupy the entire side of a slope.

The surface layer is dark grayish brown or dark brown and is 3 inches or less thick. The subsoil in many places is only 24 to 36 inches thick. It is not so fine textured as that in less sloping Sharpsburg soils. Runoff is rapid, and this soil is subject to further sheet and gully erosion.

Included with this soil are small areas that have a surface layer that is 3 to 7 inches thick. Also included are a few areas that have slopes of as much as 25 percent.

Most areas of this Sharpsburg soil are in permanent pasture, which is a good use. Under good management that includes pasture renovation, many of the pastures can be made more productive. Terracing the less sloping soils upslope and farming them on the contour are ways to protect this soil from further erosion and gullying. The many gullies that have formed in this soil need to be filled, shaped, and seeded to grass for use as waterways. Additions of barnyard manure and fertilizer are needed, especially when pastures are being renovated. Capability unit VIe-1.

Shelby Series

The Shelby soils are dark colored and are well drained to moderately well drained. They formed under prairie grasses in the uplands, from glacial till of Kansan or Nebraskan time. Slopes range from 5 to 30 percent, but in most places are from 9 to 18 percent. The areas generally are on the lower parts of side slopes and on long ridges, but in a few places where the landscape is strongly dissected, they occupy the entire side slope. Shelby soils are near the Marshall and Sharpsburg soils, which formed in loess, and the Adair and Clarinda soils, which formed in glacial material. In some places Shelby soils are just below small, narrow areas of soils similar to the Adair soils, and these areas are shown on the soil map by a clay spot symbol.

The surface layer of these soils is black, friable heavy loam in the upper part and very dark grayish-brown, friable light clay loam in the lower part. It has fine granular to fine subangular blocky structure and is about 14 inches thick. The subsoil extends to a depth of about 40 inches. It is yellowish-brown, mostly firm clay loam, has subangular blocky structure, and has a few light brownish-gray mottles in the lower part. The substratum is yellowish-brown, firm, massive light clay loam and has yellowish-brown and brownish-gray mottles. It is calcareous and in some places contains concretions of calcium carbonate.

Permeability of the subsoil is moderately slow in these soils, and the available moisture capacity is high. The content of organic matter is low. Shelby soils are low to very low in available nitrogen and in phosphorus and medium to low in potassium. They generally are slightly acid to medium acid.

In places Shelby soils are intermingled with Adair soils and with Clarinda soils and are mapped in complexes with those soils. Shelby soils generally make up 50 percent of each complex; Adair soils, 35 percent; and Clarinda soils, 15 percent. In many areas Clarinda soils are lacking, and here either the Shelby or Adair soil may occupy from 40 to 60 percent of any one area. If present in these complexes, Clarinda soils generally occupy the wet, seepy areas at the heads of upland drainageways. The Adair and Clarinda soils are described under their respective series.

Representative profile of Shelby loam on a slope of 11 percent that faces north (300 feet east and 60 feet north of the southwest corner of the SE¼SE¼ sec. 20, T. 75 N., R. 34 W.):

Ap—0 to 8 inches, black (10YR 2/1) heavy loam; weak, thin, platy structure that breaks to weak, fine, subangular and weak, fine, granular; seems compacted; friable; a few pores; medium acid; clear boundary.

A3—8 to 14 inches, very dark grayish-brown (10YR 3/2) light clay loam that has a few peds of dark brown to brown (10YR 4/3); weak, fine, subangular blocky structure that breaks to moderate, fine and very fine, granular structure; friable; peds are covered with sand particles; a few very small pebbles; medium acid; clear boundary.

B1—14 to 25 inches, yellowish-brown (10YR 5/4) light clay loam; moderate, fine and medium, subangular blocky structure; dark-brown to brown (10YR 4/3) ped exteriors; friable to firm; in some places mixing of very dark gray (10YR 3/1) material through biological activity; medium acid; gradual boundary.

B2t—25 to 33 inches, yellowish-brown (10YR 5/4) medium clay loam; moderate, medium, subangular blocky structure; dark yellowish-brown (10YR 4/4) ped exteriors; firm; many black (10YR 2/1) stains and thin, discontinuous films on peds; a few small pebbles; medium acid; gradual boundary.

B3t—33 to 41 inches of light clay loam, the peds of which have yellowish-brown (10YR 5/4) interiors and dark yellowish-brown (10YR 4/4) exteriors; a few, fine, distinct mottles of light brownish gray (2.5Y 6/2); weak, medium, prismatic structure that breaks to moderate, coarse, subangular blocky; firm; thin, discontinuous films on ped surfaces; many dark oxides; slightly acid; clear boundary.

C—41 to 58 inches, yellowish-brown (10YR 5/4) and dark-brown (10YR 3/3) light clay loam with a few faces of dark brown to brown (10YR 4/3); common, fine, distinct mottles of yellowish brown (10YR 5/8); very weak, coarse, subangular blocky structure to massive; firm; common light brownish-gray (2.5Y 6/2) streaks in soil matrix; many dark oxides; calcareous and contains calcium carbonate concretions.

The surface layer is black to very dark grayish brown. It is 8 to 12 inches thick in relatively uneroded areas but is as thin as 3 inches in steep, eroded areas. The texture generally is loam, but it ranges to clay loam in severely eroded areas or where material from the subsoil is mixed in the plow layer. The subsoil is dark brown to yellowish brown and has strong-brown, olive-gray, and grayish-brown mottles at a depth below 30 inches. It generally is between 1½ and 3 feet thick. The texture is clay loam, and the clay content ranges from 32 to 40 percent. The underlying material is yellowish brown and mottled and generally is calcareous at a depth between 30 and 50 inches. Pebbles and stones are common throughout the profile.

Shelby soils typically have a thicker surface layer than Gara soils. They also lack the light-colored subsurface horizon and grainy coatings in the subsoil that are typical of those soils, and they are less acid in the subsoil. Their subsoil is not so clayey nor so reddish as that in the Adair soils.

Shelby loam, 5 to 9 percent slopes, moderately eroded (ShC2).—Many areas of this soil are on rounded, moderately sloping divides, just below gently sloping ridgetops. Others are just below long, moderately sloping, extended ridges on slopes that adjoin soils on first bottoms or in drainageways. The areas are downslope from the Marshall, Sharpsburg, Adair, and Clarinda soils and are between 5 and 30 acres in size.

In most places the surface layer is very dark grayish brown and is about 3 to 7 inches thick. In about 20 percent of the acreage, however, the soil is severely eroded, and here all but 3 inches or less of the original surface soil has been washed away. The present surface layer consists largely of material from the subsoil that has been mixed with the remaining surface soil by plowing. It is dark grayish brown to dark brown and in places is clay loam in texture. The severely eroded areas are shown on the detailed soil map by the symbol for severe sheet erosion.

Included with this soil are a few acres of a soil that has a black to very dark gray surface layer 7 to 12 inches thick.

Many areas of this Shelby soil are used for cultivated crops, but some are used for pasture. Much of the acreage has been cropped intensively, and the fertility and content of organic matter are low in many places.

If this soil is used for row crops, terracing and farming on the contour are needed. Filling in gullies and seeding the areas to grass for use as waterways permit safe removal of excess rainfall. The waterways also provide a crossway for tillage implements. Crops respond if fertility is kept high, and if other good management is used. Renovating the pastures increases their carrying capacity. Capability unit IIIe-1.

Shelby loam, 9 to 14 percent slopes (ShD).—Areas of this soil are between the higher lying Adair, Clarinda, Marshall, and Sharpsburg soils and soils in upland drainageways or on bottom lands. They generally are on the lower parts of side slopes, but in places they are just above steeper Shelby soils. The individual areas are between 5 and 25 acres in size.

This soil has a black or very dark gray surface layer, but its profile otherwise is similar to the profile described as representative for the series. The texture is dominantly loam, but in some small areas near drainageways that cut into sidehills it is clay loam. In places near the base of long slopes the surface layer is likely to be more than 12 inches thick because of local alluvium washed onto the areas from soils upslope.

Included with this soil are some severely eroded areas less than 2 acres in size. These are shown on the soil map by the symbol for severe sheet erosion.

This Shelby soil can be used for row crops, but much of the acreage is used for pasture. It is subject to severe erosion when cultivated. The cultivated areas generally are farmed along with other soils more suitable for cultivation. The response of crops is moderate.

If this soil is used for row crops, terracing and contour farming are needed for control of erosion. Grassed waterways also should be established where needed. The productivity of the pastures can be increased through renovation. Capability unit IIIe-3.

Shelby loam, 9 to 14 percent slopes, moderately eroded (ShD2).—This soil generally is between areas of higher lying Adair, Clarinda, Ladoga, Marshall, and Sharpsburg soils and Judson-Colo complex, 2 to 5 percent slopes, in drainageways. In a few places, however, it is just above areas of the Marshall or Sharpsburg soils. The individual areas generally are between 5 and 40 acres in size.

Most areas of this soil have a surface layer of very dark gray or very dark grayish-brown loam 3 to 7 inches thick. In some places yellowish-brown material from the subsoil has been mixed with the remaining original surface layer by plowing. Depth to limy material varies within a short distance, but it generally is between 30 and 50 inches.

Included with this soil are many areas of Adair and Clarinda soils that are too small to be mapped separately.

This Shelby soil is moderately well suited to cultivation, and in many places it is cropped along with surrounding soils. In some areas shallow gullies have formed, and these need to be filled, shaped, and seeded to permanent vegetation. If this soil is used for row crops, contour farming and terracing are needed to prevent further sheet and gully erosion. The hazard of erosion can be reduced on this soil by using suitable practices for erosion control on the soils upslope. Capability unit IIIe-3.

Shelby loam, 14 to 18 percent slopes (ShE).—This soil generally is on the lower part of side slopes between higher lying Adair and Clarinda soils and Judson-Colo complex, 2 to 5 percent slopes, in upland drainageways. In places it is just above soils on first bottoms. The areas occur throughout the county and range from 5 to 30 acres in size.

The surface layer is very dark gray and generally is 7 to 12 inches thick. It may be nearly 15 inches thick near the base of long slopes where local alluvium washed from the upper part of the slope covers the areas. In many places this soil is calcareous at a depth of about 36 to 40 inches. In places near the shoulders of the slope in areas now cultivated or that formerly were cultivated, material from the subsoil has been mixed with the surface soil by plowing. Here the surface layer is very dark grayish-brown light clay loam.

Included with this soil are small areas of severely eroded Shelby soils less than 2 acres in size. These areas are shown on the soil map by the symbol for severe sheet erosion.

This Shelby soil is better suited to hay or pasture than to cultivated crops, and most areas are in permanent pasture. It can be used only occasionally for row crops because it erodes severely when cultivated. Small areas generally are farmed along with adjoining soils that are more suitable for row crops. In places gullies have formed in this soil, and these need to be filled, shaped, and seeded to grass for use as waterways. Capability unit IVe-1.

Shelby loam, 14 to 18 percent slopes, moderately eroded (ShE2).—This soil generally is just below ridges that have a cover of loess and just above soils in upland drainageways or on first bottoms. In many places the areas occupy the entire side of a slope. The areas are from 5 to 30 acres in size and occur throughout the county.

The surface layer is very dark grayish-brown or very dark gray loam 3 to 7 inches thick. In places dark-brown material from the subsoil has been mixed in the surface layer by plowing. In some places at the base of slopes and near drainageways that cut into sidehills, the surface layer is more than 7 inches thick. Here the areas have a cover of local alluvium that washed onto the areas from the upper part of the slopes. In places this soil is calcareous at a depth of about 36 inches. In many places stones are on the surface.

This soil is better suited to hay and pasture than to cultivated crops, and some areas are in permanent pasture. The soil erodes severely when cultivated. Also tilth is quite poor. The areas can be used occasionally for row crops when establishing stands of hay or renovating pasture. Response to fertilizer is good. Gullies in the areas need to be smoothed over and seeded to grass. Capability unit IVe-1.

Shelby loam, 18 to 25 percent slopes, moderately eroded (ShF2).—This soil generally occupies irregular, complex slopes along stream valleys. Much of the acreage is in Grant Township and along the East Nishnabotna River. The individual areas are between 10 and 30 acres in size.

The surface layer is very dark grayish brown and generally is 3 to 7 inches thick. The subsoil is thinner than that in less steep Shelby soils that are moderately eroded. Depth to the calcareous Kansan till generally is about 30 inches or more.

Small areas of gravel are common on the surface of this soil, and limy glacial till is exposed on some sharp convex slopes. In places moderately deep gullies cut across the length of the areas. In a few places dark-brown clay loam from the subsoil is exposed. Loamy local alluvium 8 to 10 inches thick has accumulated in many places near the base of slopes and near drainageways that cut into sidehills. The alluvium washed onto the areas from soils upslope. Included with the areas mapped as this soil are some areas that have a surface layer of very dark gray loam 7 to 12 inches thick.

This Shelby soil generally is in permanent pasture. The soil is too steep and erodible for cultivated crops. In places the slopes also make it difficult to renovate the pastures. Controlling grazing helps to keep a protective cover on the areas and thus prevents gullying. Capability unit VIe-1.

Shelby soils, 9 to 14 percent slopes, severely eroded (SsD3).—These soils occupy narrow areas on the lower parts of slopes. The areas are between the Adair, Clarinda, Marshall, and Sharpsburg soils on higher slopes and soils in upland drainageways and on first bottoms. They range from 5 to 40 acres in size.

All but about 3 inches of the original surface layer of this soil has been removed through erosion. The present surface layer is firm, dark grayish-brown or dark-brown clay loam in most places. The texture ranges from loam to clay loam, however, depending on how much of the original surface layer has washed away. The subsoil is thinner than that in less eroded Shelby soils on similar slopes. Depth to the calcareous glacial till generally is between 30 and 36 inches. Small spots of gravel occur on the surface. Many areas near the upper edges of these soils are very severely eroded and are difficult to cross with tillage equipment.

These soils are well suited to hay and pasture crops, but row crops can be grown only occasionally. The steep slopes and severe hazards of runoff and erosion make the soils poorly suited to row crops. Also the surface seals over after a rain, and tilth is poor. The areas generally are cropped the same as the surrounding soils that are better suited to row crops.

If these Shelby soils are used for cultivated crops, terracing and contour farming are needed to reduce runoff and prevent further erosion. Gullies that have formed in the areas ought to be filled, shaped, and seeded to grass for use as waterways that can be crossed with farm machinery. Renovating the pastures increases their carrying capacity. Capability unit IVe-1.

Shelby soils, 14 to 18 percent slopes, severely eroded (SsE3).—These soils are on moderately long side slopes just below Adair, Clarinda, Marshall, and Sharpsburg soils. In many places the areas extend downslope to soils of the bottom lands. The slopes in many places are irregular and the sidehills are dissected by gullies. The areas occur throughout the county but are mainly in rough, dissected areas along the major streams. Individual areas range from 5 to 40 acres in size.

All but about 3 inches or less of the original surface layer of these soils has been lost through erosion. The present surface layer is dark grayish-brown to dark-brown loam or clay loam. The subsoil is thinner than that in less eroded Shelby soils on similar slopes. Depth to calcareous glacial till generally is between 30 and 36 inches. In some places small areas of gravel are on the surface. Also in many areas on the sharper, steeper slopes, small spots of calcareous glacial till is exposed.

These soils are not suited to row crops, because of the steep slopes and the severe erosion hazard. They are better suited to pasture. These soils are difficult to manage. Tilth is very poor, the content of organic matter is low, and the ability to absorb moisture is seriously restricted. The carrying capacity of the existing pastures can be increased by renovating them. Filling in the gullies and seeding them to grass are means of obtaining safe removal of excess runoff and making it possible to use farm machinery on the areas. Capability unit VIe–1.

Shelby soils, 18 to 30 percent slopes, severely eroded (SsF3).—These soils occupy steep, irregular side slopes just above upland drainageways and narrow first bottoms. They generally are just below Adair and Clarinda soils, but in many places they are just below Sharpsburg and Marshall soils on gently sloping ridgetops. The largest acreage is in Grant Township, though small areas occur throughout the steeper parts of the county. Individual areas range from 5 to 25 acres in size.

These soils are cut by gullies in many places. The present surface layer is dark grayish-brown or dark-brown clay loam or loam 3 inches or less thick. The subsoil is 24 to 30 inches thick. A few small areas are calcareous at the surface, and these are shown on the soil map by a spot symbol.

Included with these soils are small, very steep areas that have a surface layer that is 3 to 7 inches thick. Also included are one or two small areas that are only slightly eroded and have a black to very dark grayish-brown surface layer 7 to 12 inches thick.

These Shelby soils are not used for crops. They generally are used for pasture, but some areas have a few scattered trees on them, and a brushy undergrowth. Overgrazing and erosion have reduced the supply of organic matter, lowered the fertility, and decreased the ability of these soils to absorb moisture. The steep slopes make it difficult to use farm implements. Nevertheless, permanent pastures ought to be renovated if feasible. Controlling grazing helps to keep a protective cover and to prevent further erosion. Capability unit VIIe–1.

Shelby-Adair complex, 5 to 9 percent slopes, moderately eroded (SyC2).—In many places this complex is on the sides of long, rounded, sloping ridges below soils formed in loess on the ridgetops. In many other places the areas are upslope from steeper Shelby-Adair complexes and from more sloping Shelby soils that are mapped separately. Some areas occupy the lower part of side slopes around and through coves at the heads of upland drainageways. Still other areas are upslope from Shelby soils that are mapped separately, and upslope from soils in upland drainageways. Individual areas generally are between 5 and 20 acres in size.

The surface layer generally is between 3 and 7 inches thick. It typically is clay loam or loam in the Shelby soil, and gritty silty clay loam or clay loam in the Adair soil. This complex has a higher proportion of Clarinda soils than any other Shelby-Adair complex and is less sloping. It therefore is likely to be wetter.

The content of organic matter in the soils of this complex is low, especially in areas that have been cropped heavily. The capacity to absorb moisture also is low. Tilth is poor, runoff is quite high, and the soils are subject to sheet and gully erosion. Areas that adjoin soils on loess upslope generally are wet and seepy in spring. The soils in these areas become hard and cloddy as they dry, and deep cracks commonly form in them when they are cultivated. Stones and pebbles are on the surface in many places where erosion has removed the original surface layer. Small gullies are common in the sides of valleys.

Included with this complex are some severely eroded areas in which the subsoil of clay loam or clay is exposed. Also included are about 5 acres that are only slightly eroded.

Many areas of this complex are used for cultivated crops. A protective cover of vegetation must be kept on these soils or other practices used for the control of erosion. If row crops are grown, terracing and farming on the contour is needed, though placing terraces in the Adair part of the complex ought to be avoided. Placing interceptor tile upslope in the more permeable soils provides drainage in wet, seepy areas. Small gullies need to be filled, shaped, and seeded to grass for use as waterways. These sodded waterways also provide a crossing for tillage implements. Capability unit IIIe–2.

Shelby-Adair complex, 9 to 14 percent slopes (SyD).—This complex is just below areas of Ladoga, Marshall, and Sharpsburg soils. In many places it occupies the lower part of side slopes and grades to areas of Judson-Colo complex, 2 to 5 percent slopes, in upland drainageways. In other places the areas adjoin soils upslope on loess. The areas are fairly small and are scattered throughout the county.

The surface layer of the soils in this complex generally is between 7 and 12 inches thick. It generally is loam in the Shelby soil and gritty silty clay loam or clay loam in the Adair soil. In some places near the lower boundary of areas of this complex, the surface layer is thicker than described. At the upper edge of some areas are small, severely eroded areas, and these are shown on the detailed soil map by the symbol for severe erosion.

The soils in this complex are poorly suited to cultivation and are subject to severe erosion if worked intensively. Tilth is fair, however, if the soils are not worked when wet. This complex ought to be in hay or pasture most of the time, and many areas are in permanent pasture. A row crop can be grown occasionally in the cropping sequence. Some areas, however, are used more frequently for row crops because the soils surrounding them are better suited to cultivation.

If row crops are grown on these soils, terracing and farming on the contour are needed, though placing terraces in the Adair part of the complex ought to be avoided. Wetness caused by seepage can be reduced in many places by installing interceptor tile in areas just above this soil. Gullies in the areas need to be filled and seeded to permanent grasses for use as waterways. Under good management, including adequate amounts of fertilizer, the response of pasture crops is good. Capability unit IVe–1.

Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded (SyD2).—This is the most extensive Shelby-Adair complex mapped in the county. It generally is downslope from Ladoga, Marshall, and Sharpsburg soils and in many places occupies the entire lower part of the side slope. The areas generally slope downward to narrow, upland drainageways. Many other areas, however, are on side slopes adjacent to other Shelby-Adair complexes or to Shelby soils that are mapped separately.

The surface layer generally is between 3 and 7 inches in thickness. It typically is clay loam or loam in the Shelby soil and gritty silty clay loam or clay loam in the Adair soil. In many places plowing has exposed the clayey subsoil, and here the surface layer varies in color, texture, and thickness.

Much of the original surface layer of these soils has been lost because of excessive tillage. Tilth generally is quite poor, and if these soils are cultivated when wet, they become cloddy when dry and cracks form in them. Gullies are common in the sides of the hills.

The soils in this complex are poorly suited to row crops. Some areas, however, are cropped along with surrounding soils better suited to row crops. The areas are best kept in hay or pasture most of the time, though a row crop can be grown occasionally.

If row crops are grown on these soils, terracing and farming on the contour are needed for control of sheet and gully erosion. Placing terraces in the Adair part of the complex, however, ought to be avoided. Wetness caused by seepage can be reduced by placing interceptor tile upslope in the more friable soils. Gullies in the areas need to be filled and seeded to permanent grass for use as waterways. These sodded gullies also provide a crossing for farm machinery. Capability unit IVe–1.

Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded (SyE2).—In some places this complex occupies areas between higher lying soils on ridgetops and side slopes, which have a cover of loess, and lower lying soils in upland drainageways. In other places the areas are narrow and are on the lower part of side slopes that extend into and around concave coves at the heads of drainageways.

The surface layer generally is between 3 and 7 inches thick. It typically is clay loam or loam in the Shelby soil and gritty silty clay loam or clay loam in the Adair soil. In places plowing has exposed the clayey subsoil, and here the surface layer varies in color, texture, and thickness.

Erosion and excessive tillage have lowered the productivity of these soils. Tilth is poor. In wet seasons seepage generally occurs upslope at points adjacent to loess-covered soils and around the heads of drainageways near Clarinda soils. Pebbles and stones are on the surface in some areas and interfere with tillage and renovation practices.

Because of steep slopes, excessive runoff, wetness from seepage, and the hazard of further erosion, this complex is not suited to row crops. Hay and pasture are suitable uses. In some areas gullies have formed, and these ought to be filled and seeded to grass for use as waterways. Forage crops on this complex respond if fertilizer is added. Capability unit VIe–2.

Shelby-Adair complex, 18 to 25 percent slopes, moderately eroded (SyF2).—This complex is mostly in Grant Township between soils on ridgetops that have a cover of loess and Colo and Judson soils in drainageways. In many places the areas occupy the entire side slope.

The surface layer generally is clay loam in texture. It typically is between 3 and 7 inches in thickness, but in some small areas it is between 7 and 11 inches thick. Much of the original surface layer has been lost through erosion as the result of overgrazing and cultivation.

If these soils are cultivated, they are subject to severe erosion. Pasture is a suitable use. Because of poor tilth and strong slopes, runoff is excessive. Any gullies in the areas need to be filled, shaped, and seeded to grass to prevent further erosion. The carrying capacity of many of the pastures can be improved by renovating them and protecting them from overgrazing. Capability unit VIIe–1.

Shelby-Adair complex, 18 to 30 percent slopes, severely eroded (SyF3).—Most of this complex is in Grant Township on steep, irregular side slopes that border major streams and their tributaries. Many areas are cut by gullies that cannot be crossed with farm machinery.

All but about 3 inches of the original loam to clay loam surface layer of these soils has been washed away. In most places clay loam to clay material formerly in the subsoil is on the surface. In some places stones and pebbles are on the surface. The hazard of further erosion is severe.

Most of this complex is pastured, but some areas have scrub timber growing on them. The soils are suited to moderate grazing. They are also suitable for use as wildlife habitats. The carrying capacity of the pastures is quite low, and the steep, irregular slopes make pasture renovation difficult. Capability unit VIIe–1.

Wabash Series

In the Wabash series are dark-colored, very poorly drained soils. These soils formed in aluvium on first bottoms and on low stream benches in areas where streams from uplands enter the Nishnabotna River valley. The native vegetation was trees and grasses that could tolerate wetness.

Most of the Wabash soils that have a silty clay surface layer are on moderately wide and broad bottom lands in all parts of the county, but a few small areas are on higher bottom lands. These silty clay soils generally are adjacent to upland slopes that border flood plains and thus are some distance back from the stream channel. They are associated with the Colo, Kennebec, and Zook soils. Wabash soils that have a surface layer of silty clay loam are mainly in old slack water areas on low stream benches along the East Nishnabotna River. They are associated with soils of the Bremer, Nevin, and Zook series.

The surface layer of Wabash soils is black, firm silty clay or silty clay loam. It has fine and very fine subangular blocky structure and is about 28 inches thick. In places the lower part is very dark gray. The subsoil is very dark gray and dark-gray, very firm silty clay. It has weak prismatic structure that breaks to angular blocky.

Wabash soils have high content of organic matter and available moisture capacity. Permeability of the subsoil is slow or very slow. These soils generally are wet because of a perched water table. Some low areas also are subject to flooding, and in many places water stands in ponds. Wabash soils are low to medium in available nitrogen, medium in available phosphorus, and medium to high in potassium. They generally are slightly acid or medium acid. Small, extremely wet areas less than 2 acres in size are shown on the detailed soil map by a spot symbol.

Representative profile of Wabash silty clay on a nearly level bottom land of the East Nishnabotna River (250 feet north and 100 feet east of the center of the road from the southwest corner of the SE¼NW¼ sec. 13, T. 77 N., R. 36 W.):

Ap—0 to 6 inches, black (10YR 2/1 and very dark grayish-brown (10YR 3/2) light silty clay to heavy silty clay loam; weak, fine, subangular blocky structure; friable; this horizon may consist of overwash; medium acid; clear boundary.

A13—6 to 15 inches, black (N 2/0) silty clay that is black (10YR 2/1) when crushed; moderate, very fine, subangular blocky structure; firm; slightly acid to medium acid; gradual boundary.

A3—15 to 28 inches, black (N 2/0) or very dark gray (N 3/0) silty clay; weak, fine and very fine, subangular blocky structure; firm to very firm; continuous sheen on vertical faces of peds and discontinuous sheen on horizontal faces of peds; medium acid; gradual boundary.

B21g—28 to 36 inches, very dark gray (N 3/0) silty clay; weak, medium, prismatic structure that breaks to weak, medium, angular blocky; very firm, continuous sheen on vertical faces of peds and discontinuous sheen on horizontal faces of peds; slightly acid to medium acid; gradual boundary.

B22g—36 to 48 inches, very dark gray (N 3/0) silty clay; common, medium, faint mottles of dark gray (5Y 4/1); weak, medium, prismatic structure that breaks to moderate, medium, angular blocky; very firm; discontinuous sheen on the faces of some peds; a few dark-brown oxides; slightly acid to medium acid; gradual boundary.

B3g—48 to 55 inches, dark-gray (5Y 4/1) silty clay; common, medium, distinct mottles of pale olive (5Y 6/3) and a few, fine, distinct mottles of yellowish brown (10YR 5/8); massive, with some vertical cleavage; very firm; discontinuous sheen on cleavage faces; slightly acid to medium acid.

Wabash soils generally are black or very dark gray to a depth of more than 36 inches, and below that depth they are dark gray or gray. The soils that have a light silty clay surface layer generally grade to medium silty clay with depth. Those that have a surface layer of medium silty clay loam are this texture to a depth of 15 to 20 inches. The subsoil of all these soils is silty clay or clay to a depth of several feet, and it is 46 to 60 percent clay. Wabash soils generally are firm or very firm in consistence.

These soils have a more slowly permeable subsoil than Zook soils and contain about 10 percent more clay.

Wabash silty clay (0 to 2 percent slopes) (Wa).—This soil occupies variable positions on the bottom lands. Many areas are near the base of upland slopes, but some areas are adjacent to stream channels. Some of the areas are as large as 100 acres.

This is the most extensive Wabash soil mapped in the county, and its profile is like the one described as representative for the series. The areas generally are wet because of overflow from nearby streams or because of a high water table. Many areas are at a lower elevation than adjacent soils next to stream channels, and many areas also receive runoff from adjacent uplands. This soil generally is in poor tilth. It puddles if worked when wet and becomes hard and cloddy as it dries. Weed control also is a problem in most years.

Included with this soil are some areas of Colo, Judson, Kennebec, and Zook soils and other soils of the bottom lands. These included soils are too small to be mapped separately.

This soil generally is farmed along with surrounding soils, though some areas are large enough to be farmed separately. Many areas are in pasture. If wetness is controlled, this Wabash soil is suited to growing row crops often. The response of crops generally is medium.

If outlets can be obtained, wetness can be reduced by using open ditches or shallow natural drains. Tile drains do not work in this soil because of the very slowly permeable subsoil. Constructing diversion terraces at the base of adjoining slopes helps to reduce overflow from runoff. Capability unit IIIw-1.

Wabash silty clay loam (0 to 2 percent slopes) (Wb).—This soil is on low alluvial benches, mainly along the East Nishnabotna River. It generally is near Bremer and Nevin soils, but some areas on stream benches are surrounded by Minden and Marshall soils. Some areas are as large as 90 acres in size.

The profile of this soil is similar to the one described as representative for the series. Poor internal drainage and occasional ponding limit use. Also in years when rainfall is above normal, control of weeds is difficult.

Included with this soil are some areas of a soil that is grayer at a shallower depth than this soil and some areas that are not so poorly drained. Also included are about 500 acres of a soil that has a deposit of very dark grayish-brown silt loam or silty clay loam on the surface, and under this, a silty clay. A few included acres are severely channeled. All of the included soils are in areas too small to be mapped separately.

This Wabash soil generally is farmed to row crops along with surrounding soils. Many areas, however, are large enough to be farmed separately.

If wetness is reduced, this soil is suitable for growing row crops often. In most places open ditches and natural surface drains can be used to provide drainage. Tile drains do not work well in this soil. Capability unit IIIw-1.

Zook Series

The Zook series consists of dark-colored soils that are poorly drained. These soils formed in alluvium on first bottoms under trees and grasses that could tolerate wetness.

Some of the Zook soils are in slack water areas on old stream benches. Many areas are parallel to streams, and many other areas are adjacent to slopes in the uplands that border many of the flood plains. Areas that are some distance back from the channel of a stream generally are at a lower elevation and receive floodwater from higher lying areas. Ponding of water thus occurs in some places. Also areas along major channels that have not been straightened are likely to be flooded. Zook soils generally are associated with soils of the Colo, Kennebec, Nodaway, and Wabash series. Areas of Zook soils that are less than 2 acres in size and that are extremely wet are shown on the detailed soil map by a spot symbol.

The surface layer is black, friable to firm silty clay loam. It has very fine subangular blocky structure and is about 20 inches thick. The subsoil, which extends to a depth of more than 50 inches, is very dark gray in the upper part and gray in the lower part. It is firm silty clay and has subangular blocky structure.

Permeability of the subsoil is slow to very slow. The areas are wet early in spring and cannot be worked until later in the season. Row crops can be grown if artificial drainage is provided. In many places diversion terraces can be used to reduce flooding and ponding. Zook soils are low in available nitrogen and phosphorus, low to medium in potassium, and generally are slightly acid or medium acid.

Representative profile of Zook silty clay loam on a bottom land with a slope of about 1 percent (600 feet west and 210 feet north of the southwest corner of SW¼ sec. 5, T. 76 N., R. 37 W.):

Ap—0 to 6 inches, black (10YR 2/1) medium silty clay loam; weak, fine, granular structure that breaks to weak, very fine, subangular blocky; friable; many very fine roots; compacted; medium acid; clear boundary.

A12—6 to 14 inches, black (N 2/0) medium silty clay loam; moderate, very fine, subangular blocky structure; friable to firm; sheen of moisture on peds; slightly acid; gradual boundary.

A13—14 to 20 inches, black (N 2/0) medium silty clay loam; moderate, medium, subangular blocky structure; friable to firm; thin, continuous sheen on vertical and horizontal faces of peds; slightly acid; gradual boundary.

B1—20 to 38 inches, black (10YR 2/1) silty clay that is very dark gray (10YR 3/1) when kneaded; moderate, medium, subangular blocky structure; firm; thin, continuous sheen on vertical and horizontal faces of peds; slightly acid to medium acid; gradual boundary.

B2g—38 to 52 inches, very dark gray (10YR 3/1) silty clay that is dark gray (10YR 4/1) when kneaded; weak, medium, subangular blocky structure; firm; continuous sheen on faces of peds; a few, fine, dark oxides; slightly acid to medium acid; gradual boundary.

B3g—52 to 65 inches, dark-gray (5Y 4/1) silty clay that grades to gray (5Y 5/1) with depth; massive with some vertical cleavage; firm; a few dark oxides; slightly acid to medium acid.

Zook soils typically are black to very dark gray to a depth of 40 inches or more, but below that depth they normally are very dark gray or dark gray. Mottles in the upper 3 feet seldom can be identified because they are masked by the dark colors. Overwash Zook soils have 6 to 16 inches of very dark grayish-brown, recent sediment of silt loam and silty clay loam on the surface. The subsoil in Zook soils generally occurs at a depth of about 20 inches. It is silty clay, and the clay content is 40 to 45 percent. Zook soils are firm to very firm in consistence. Boundaries between soil layers are gradual to diffuse.

Zook soils are dark colored to a greater depth than Bremer soils, and their subsoil is more clayey than that in Colo soils. They contain less clay than Wabash soils.

Zook silty clay loam (0 to 2 percent slopes) (Zo).—This soil occurs throughout most of the county on first bottoms of streams, but some areas are on second bottoms along the East Nishnabotna River. Some of the areas are adjacent to stream channels, and others are in shallow depressions adjacent to sloping uplands. This soil generally is associated with Colo, Kennebec, and Nodaway soils and with Wabash silty clay, though areas near the uplands are associated with the Judson soils. Individual areas are quite large; some are as much as 160 acres.

This is an extensive soil on bottom lands in the county. Its profile is like the one described as representative for the series. The surface soil puddles readily if worked when wet; and it becomes hard and cloddy as it dries. The areas are subject to occasional overflow, and unless drainage is provided, water stands on them for many days at a time. Control of weeds is likely to be difficult in wet years.

Included with this soil are some areas of Wabash silty clay. These included areas are too small to be mapped separately.

This Zook soil is suited to growing row crops frequently if artificial drainage is provided. It is also suited to pasture. The areas generally are large enough to be farmed separately, but many areas are farmed along with closely associated soils.

Tile drains generally work in this soil, even though the subsoil is clayey. In many places tile drains, together with natural surface drains and open ditches, are needed to reduce wetness. Performing all tillage operations toward natural surface drains also helps to control wetness. Capability unit IIw-1.

Zook silt loam, overwash (0 to 2 percent slopes) (Zk).—Many areas of this soil are adjacent to stream channels, but many other areas adjoin upland slopes and are some distance from a stream. This soil is associated with the Colo, Kennebec, and Nodaway soils and with Wabash silty clay on first bottoms. The areas are on bottom lands throughout the county. Some of the areas are as much as 75 acres in size.

This soil has from 6 to 16 inches of very dark grayish-brown, recent sediment of silt loam and silty clay loam on the surface, but otherwise it is similar to Zook silty clay loam. The sediment on this soil was washed from nearby upland slopes or deposited by overflow from nearby streams. The content of organic matter is much lower in the overwash on this soil than in the material just below. If this soil is not too wet, it is quite easy to work.

Zook silt loam, overwash, can be used frequently for row crops. It is managed much the same as Zook silty clay loam. Crops on this soil respond better than those on Zook silty clay loam, because the surface soil is better drained and is easier to work. Correcting the wetness is the major problem in managing this soil. Capability unit IIw-1.

Use and Management of the Soils

This section briefly describes the system of capability classification used by the Soil Conservation Service; discusses the use and management of groups of soils, or capability units; and gives a table showing the estimated acre yields of the principal crops for all of the soils in the county. In addition it discusses woodland and names trees suitable for planting on each of the soils in the county and briefly discusses wildlife.

Capability Groups of Soils

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 to rice and other crops having special requirements. The soils are classified according to degree and kinds of permanent limitation, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible major reclamation.

In the capability system all soils are grouped at three levels, the capability class, subclass, and unit. These are discussed 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 some 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 restrict the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

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

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

Class VIII soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (None in Cass 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-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in Cass 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*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. 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.

Management by Capability Units

In the following pages the capability units in Cass County are described and suggestions for use and management of the soils are given. The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all 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 Mapping Units" at the back of this survey.

Capability unit I–1

The soils in this capability unit are nearly level, deep, and well drained to somewhat poorly drained. These soils are in the Marshall, Minden, Nevin, and Sharpsburg series. They are in the uplands or are on stream benches. Their surface layer is friable to firm silty clay loam.

The content of organic matter in these soils is medium to high, and fertility is high. Permeability of the subsoil is moderate to moderately slow. These soils readily absorb rain when it falls in normal amounts, and they hold much of this moisture available for plants. Tilth generally is good and is easy to maintain. The Minden soil, however, stays slightly wet in places in spring. It puddles if tilled when wet and becomes cloddy as it dries out.

These soils are easy to manage. Row crops can be grown almost every year. Corn is the major crop, but small grain, grain sorghum, soybeans, and hay and pasture crops are also grown. Controlling weeds and insects, plowing under crop residues, and adding fertilizer in amounts required are the major practices needed for maintaining optimum yields and keeping the soils in good tilth. Erosion is not a hazard.

Many areas of these soils could be farmed separately, but most areas are farmed with other soils that are suited to similar crops. If row crops are grown most of the time, turning under green-manure crops helps to maintain the supply of organic matter and to maintain soil tilth and structure. Growing meadow crops for 1 year in the cropping system is another way of maintaining tilth and also helps in controlling weeds and insects.

Lime generally is needed on these soils, and corn that is not preceded by a good stand of legumes benefits if nitrogen and phosphate are applied. Small grains respond well to phosphate. Applications of potash generally are not needed in large amounts.

Capability unit I–2

Soils in this capability unit are nearly level, deep, and well drained to somewhat poorly drained. These soils are in the Judson, Kennebec, and Nodaway series. They are on bottom lands or are on low alluvial fans. The surface layer of all of these soils is friable silt loam.

The soils in this unit are easy to work. Permeability of the subsoil is moderate. The content of organic matter generally is high in the Judson and Kennebec soils and moderately low in the Nodaway soil. Some areas of the Kennebec soil, however, have a cover of overwash, and in these places the content of organic matter is low to medium. Air and water movement within the profile is good. These soils generally warm up early in spring, dry out quickly, and are in good tilth; thus, they are easy to manage. Erosion is not a hazard.

In some places Judson and Kennebec soils are slightly wet in years when rainfall is above normal. Other areas of Kennebec soil and some areas of Nodaway soil are subject to flooding for short periods in years when rainfall is excessive. The floodwater remains for only a short period and generally does not damage crops, because the water runs off readily and internal drainage of these soils generally is good.

These soils have few limitations for row crops and generally are used for that purpose. Corn, small grain, grain sorghum, soybeans, and hay and pasture plants are crops that are suited. Many areas are large enough to be cropped separately, but most areas are farmed along with adjacent soils.

Row crops can be grown frequently on these soils if crop residues are returned to the soil to help keep the soil in good tilth and weeds and insects are controlled. Growing meadow crops for 1 year in the cropping system is another way of maintaining tilth and also helps in controlling weeds and insects. Placing diversion terraces upslope from the Judson soil generally protects this soil from runoff from higher lying areas. Such terraces can also be used to protect the Kennebec and Nodaway soils from runoff in periods when rainfall is excessive. Another way to control runoff is to perform all tillage operations toward natural outlets.

Lime is needed in some places on these soils. Response to fertilizer is good. Nitrogen is required if corn is grown for the second and third year in the same field. Grain and legumes need phosphate. Potash is seldom needed in large amounts.

Capability unit IIe-1

In this capability unit are gently sloping, deep soils that are well drained to somewhat poorly drained. These soils are in the Ladoga, Marshall, and Sharpsburg series. They are in the uplands or are on stream benches. Their surface layer is friable silt loam or silty clay loam.

Except for the Ladoga soils, the content of organic matter is quite high. Fertility is high in all of the soils. Permeability of the subsoil is moderate to moderately slow. These soils absorb rainfall readily. They have high available moisture capacity and are easy to work and keep in good tilth. Sheet erosion is a hazard unless practices are used for control of erosion and management is otherwise good. Soil blowing is likely if these soils are plowed in fall.

These soils are well suited to corn, small grain, soybeans, and grain sorghum, and to rotation hay or pasture. Some areas are large enough to be farmed separately, but most areas are farmed the same as surrounding soils.

The soils in the uplands require terracing and farming on the contour for control of erosion. The soils on benches need to be farmed on the contour, but terracing is impractical in some places because of irregular slopes. Runoff from the adjacent uplands needs to be controlled before terraces are constructed in the soils on benches, and diversion terraces are needed in some places. In all of the soils waterways ought to be kept under a cover of sod.

If erosion is controlled by terracing and farming on the contour, row crops can be grown frequently. Then, a suitable cropping system is 3 years of row crops followed by 1 year of small grain and a green-manure crop. Leaving all crop residues, including stubble, on the soils and rough plowing the areas are methods of controlling soil blowing.

Crops on these soils respond well if fertilizer is applied. Lime generally is needed, and corn that is not preceded by a stand of legumes generally benefits if nitrogen and phosphate are applied. Potash generally is not needed in large amounts.

Capability unit IIe-2

The soils in this capability unit are gently sloping, deep, and well drained or moderately well drained. These soils are in the Judson and Olmitz series. They are on alluvial fans or low foot slopes at the base of slopes between soils of the uplands and soils on benches and bottom lands. Their surface layer is friable silt loam or loam. The subsoil is friable, or is friable to firm, light silty clay loam or clay loam.

The content of organic matter is high in the Judson soil and medium in the Olmitz soil. Permeability is moderate in the Judson soil and moderately slow in the Olmitz soil. These soils have high available moisture capacity and absorb moisture readily. They are easy to work, but in places they remain wet in spring because of seepage and runoff from nearby upland slopes. The hazard of sheet erosion is slight if these soils are cultivated intensively. Gully erosion is a hazard in some places if the soils are left unprotected.

The soils in this unit are well suited to corn, soybeans, grain sorghum, and similar cultivated crops. Some areas, however, are not cultivated, because they are associated with soils used only for pasture. The areas generally are not large enough to be farmed separately and generally are farmed the same as surrounding soils. The response of crops on these soils is good or very good.

Diversion terraces are needed in places on the lower part of adjoining upland slopes to protect these soils from runoff and from deposition of silty material. Tile drains seldom are needed.

If runoff from adjacent slopes is controlled by diversion terraces and if these soils are farmed on the contour, row crops can be grown frequently. A suitable cropping system is 3 years of row crops and 1 year of a small grain and a green-manure crop. Plowing under the green-manure crop and all crop residues adds organic matter and helps to maintain soil tilth.

Lime generally is needed on these soils. Corn that is not preceded by a good stand of legumes requires nitrogen, and small grains and legumes benefit if phosphate is added. Crops on these soils seldom need potash in large amounts.

Capability unit IIw-1

In this capability unit are nearly level to gently sloping, deep soils that are mostly poorly drained or very poorly drained. These soils are in the Calco, Colo, Judson, Nodaway, and Zook series. The Judson and Nodaway soils, however, are moderately well drained or somewhat poorly drained and are mapped in complexes with more poorly drained soils. Most of these soils are on bottom lands in places that are subject to flooding. Judson-Colo complex, 2 to 5 percent slopes, is along drainageways in the uplands. All of these soils have a friable to firm, medium-textured to moderately fine textured surface layer. Except for the Nodaway soil, the subsoil generally is moderately fine textured or fine textured.

Except for the overwash soils, the soils in this unit are dark colored and their content of organic matter is high.

Fertility also is high. The subsoil has moderately slow to very slow permeability and is poorly aerated. The periodically high water table, excess seepage from nearby slopes, and in some places flooding make these soils generally wet and slow to warm in spring. These soils hold a good amount of moisture that is available for plants. They puddle easily if worked when wet and become cloddy and hard when dry. Nevertheless, if wetness is controlled, good tilth can be maintained.

If these soils are adequately drained and are otherwise well managed, they are suited to and are used intensively for such row crops as corn, soybeans, and grain sorghum. They are also suited to wheat, oats, and hay and pasture plants. Reed canarygrass grows well in the drainageways that remain wet and are difficult to drain artificially. In places legumes are likely to drown out in years when rainfall is above normal. Some areas of these soils are large enough to be managed separately. Judson-Colo complex, 2 to 5 percent slopes, however, generally is farmed along with adjoining soils of the uplands or of adjacent bottoms.

Tile drainage, open surface drains, or both, are needed. In addition, diversion terraces are needed in places to protect the soils from overflow and deposition of silty sediment. Tile can be used in most places to provide drainage, though tile does not work well in parts of the Zook soils. Areas of Judson-Colo complex, 2 to 5 percent slopes, in upland drainageways, are subject to gullying and need diversion terraces and tile drains. The terraces help to remove excess runoff and reduce the hazard of erosion. They also make it easier to cross the drainageways with farm equipment. In places the hazard of flooding can be reduced by straightening the stream channels.

Crops on these soils respond well if wetness is controlled and if management is good otherwise. Plowing in fall generally improves tilth and makes it easier to prepare a seedbed and get the crop in on time. If row crops are grown intensively, turning under green-manure crops, adding barnyard manure, and cultivating the soils when dry are ways to improve tilth and maintain fertility. Growing meadow crops for 1 year in the cropping system is another way of maintaining tilth and also helps in controlling weeds and insects.

On these soils lime and fertilizer generally are needed. On Calco silty clay loam, lime is not required but special applications of phosphate and potash fertilizers may be needed. Nitrogen is required if corn is grown for the second and third year in the same field. Small grains and legumes respond well to phosphate. Except on Zook and Nodaway soils, which are low to medium in available potassium, potash is seldom needed in large amounts.

Capability unit IIw-2

In this capability unit are dark-colored soils that are nearly level and are poorly drained. These soils are in the Bremer and Corley series and are on benches. Their surface layer is thick, friable silty clay loam or silt loam. The subsoil is light silty clay loam to silty clay.

These soils have high content of organic matter and available moisture capacity. Permeability of the subsoil is moderately slow in the Corley soil but ranges to very slow in some places in the Bremer soil. The surface soil seals somewhat during rains and is likely to become hard and crusty when dry. These soils are slow to warm in spring and should not be worked too early. They are easy to work, however, if not wet. A periodic high water table and excessive seepage from adjacent slopes make these soils poorly drained. The Corley soil occupies shallow depressions in many places, and water ponds in them in wet seasons.

Many areas of the Bremer soil are large enough to be farmed separately, but no areas of the Corley soil are large enough. Corn, wheat, oats, soybeans, grain sorghum, and hay and pasture are the chief crops grown on these soils. The response is good if wetness is controlled, fertilizer is added, and crop residues are returned to the soil.

Artificial drainage is required in many areas of these soils. If outlets are available, tile generally is beneficial, though many areas are farmed without tile. Installing shallow surface drains and doing all tillage toward outlets of natural surface drainageways are other ways to improve drainage. If outlets are available, surface drainage can be used to drain areas of Corley soil that are ponded.

Under good management, which includes keeping fertility high and providing artificial drainage, row crops can be grown frequently. Growing meadow crops for 1 year in the cropping system is a way of maintaining tilth and also helps in controlling weeds and insects.

On these soils corn that is not preceded by a legume needs nitrogen. Legumes and small grains respond to phosphate. Potash generally is needed periodically.

Capability unit IIIe-1

In this capability unit are moderately dark colored or dark colored, moderately sloping soils that are well drained or moderately well drained. These soils are in the Judson, Ladoga, Marshall, Sharpsburg, and Shelby series. They are in the uplands or are on stream benches. Some of them are moderately eroded or severely eroded. The surface layer of these soils is friable and ranges from loam to silty clay loam in texture. The subsoil is silty clay loam to clay loam.

The content of organic matter is high in the soils that are not eroded, but it is moderately low or low in the eroded soils. Permeability of the subsoil is moderate to moderately slow. Air and water move well in these soils, and the available moisture capacity is good. These soils are easy to till and can be worked soon after a rain. Erosion is a hazard if row crops are grown.

These soils are well suited to cultivated crops if erosion is controlled, and they are used extensively for row crops and for rotation hay and pasture. Corn, soybeans, small grain, grain sorghum, and hay and pasture plants are crops that are well suited.

If these soils are used for row crops, terracing and farming on the contour generally are needed. Additional manure and fertilizer are beneficial in the terrace channels where the subsoil material is exposed. Growing a meadow crop in the cropping system and plowing it under adds organic matter and helps to keep the soils in good tilth. In waterways grass sod is needed to prevent gullies from forming in the sides of hills. Such waterways also provide additional pasture or hay and in some places seed. Soils in this unit on benches generally are not terraced because the slope pattern is irregular. These soils can be protected from runoff and erosion by use of diversion terraces.

If erosion is controlled, row crops can be grown about half of the time. Where these soils are terraced and tilled on the contour, a suitable cropping system is 2 years of row crops, 1 year of small grain, and 1 year of meadow. If only tillage is used for control of erosion, meadow crops need to be grown for a longer time in the rotation.

Lime generally is needed on these soils. Response to fertilizer is good. Corn that is not preceded by a legume requires nitrogen. Phosphate and nitrogen are generally needed at the time of seeding small grain and legumes. Potash generally is not required in large amounts.

Capability unit IIIe-2

In this capability unit are moderately sloping, moderately well drained or somewhat poorly drained soils that are moderately eroded. These soils are in the Adair and Shelby series. They overlie glacial till and have a surface layer that is friable or friable to firm and is moderately fine textured.

The content of organic matter in these soils is moderately low, but the available moisture capacity is moderately high. Permeability of the subsoil is moderately slow to very slow. The surface soil is fairly easy to till if it is not worked when too wet, but it is likely to seal over during a rain and become hard and crusty when dry. In many places these soils are wet and seepy in spring and must be worked later than surrounding soils. Many of these seepy places occur in the upper part of the soil areas near the place where soils on loess and on glacial till come into contact. All of these soils are subject to further sheet erosion and are difficult to manage if the original surface soil is washed away.

These soils are suited to cultivated crops if erosion is controlled. Most areas are cultivated, though some areas that occur with soils not suited to cultivation are pastured. Corn, grain sorghum, small grain, and hay are crops that are suited. Soybeans generally are not grown.

If these soils are used for row crops, terracing and farming on the contour are needed for control of erosion. Placing terraces and interceptor tile in the higher lying, more permeable soils on loess helps to control runoff and erosion and to reduce wetness caused by seepage. If needed, waterways should be seeded to grass. The Adair soils are not well suited to terraces, because they have irregular slopes in many places and their subsoil is slowly permeable and very low in fertility. In terrace channels additions of topsoil and manure are needed to promote growth of vegetation. If feasible, terraces in the Shelby-Adair complex ought to be placed in the Shelby soil because it is more suitable for terraces.

If erosion is controlled, row crops can be grown about half of the time. Where these soils are terraced and tilled on the contour, a suitable cropping system is 2 years of row crops, 1 year of a small grain, and 2 years of meadow. If only contour tillage is used for control of erosion, meadow crops need to be grown for a longer time in the rotation.

On these soils lime generally is needed. Corn that is not preceded by a good stand of legumes requires nitrogen. Phosphate and nitrogen generally are needed at the time of seeding small grain and legumes. Potash also generally is needed.

Capability unit IIIe-3

This capability unit consists of moderately dark colored or dark colored, strongly sloping soils that are well drained. These soils are in the Ladoga, Marshall, Sharpsburg, and Shelby series. They are in the uplands, and some areas are moderately eroded or severely eroded. The surface layer of these soils generally is friable and ranges from loam to silty clay loam in texture. The subsoil is silty clay loam or clay loam. These soils occupy the largest acreage of any capability unit in the county.

The content of organic matter in these soils ranges from moderate to low, depending upon the degree of erosion. Permeability of the subsoil is moderate to moderately slow. These soils warm up early in spring and can be worked soon after a rain. Wetness is not a problem. Runoff is rapid, and further erosion is a hazard.

The soils in this unit are used for all crops commonly grown in the county. They are well suited to corn, small grain, and grain sorghum and to hay and pasture crops. Soybeans generally are not grown. Areas of these soils generally are large and are used for cultivated crops. Some of the Ladoga and Shelby soils, however, adjoin poorer soils or steeper soils that are not suited to row crops, and these areas remain in permanent pasture.

If these soils are used for row crops, terracing and farming on the contour generally are needed for control of sheet and gully erosion. Additions of manure and fertilizer are beneficial in the channels of newly constructed terraces, where subsoil material is exposed, because the subsoil is low in fertility and generally is not very productive the first year. A cover of grass is needed in all waterways for control of gully erosion. The sodded waterways also provide additional forage and furnish a crossing for farm implements.

Row crops can be grown occasionally on these soils if erosion is controlled. Where these soils are terraced, a suitable cropping system is 1 year of corn or grain sorghum, 1 year of small grain, and 1 year of meadow. If only contour farming is used for control of erosion, meadow crops need to be grown for a longer time in the cropping system.

Lime generally is needed on these soils. Response to fertilizer is good. Corn that is grown for a second year in the same field requires nitrogen. Phosphate is needed for corn and oats and for legumes and grasses. Potash generally is not required in large amounts except on the Shelby soils, which are medium to low in potash.

Capability unit IIIs-1

Ankeny fine sandy loam is the only soil in this capability unit. It is a nearly level, somewhat excessively drained soil on low benches. The surface layer is dark-colored, friable fine sandy loam to sandy loam.

The content of organic matter in this soil is moderately low, and fertility is low. Permeability of the subsoil is moderately rapid. This soil holds only a small amount of water available for plants. It dries out quickly after a rain and is easy to till, but it is quite droughty and is subject to soil blowing.

Most areas of this soil are farmed along with surrounding soils. One area, however, is about 40 acres in size and is farmed separately.

Because this soil is droughty, the response of crops in dry years is low. In places this soil is likely to blow after plowing, and blowing sand is likely to damage young plants. Adding strawy material and leaving other crop residues on the surface help to reduce damage from blowing.

This soil is suited to growing row crops about half of the time. A suitable cropping system is 2 years of row crops, 1 year of small grain, and 1 year of meadow. Soil blowing can be further reduced if close-growing crops are grown in the cropping system for a longer time. Furthermore, some areas are better suited to forage crops than to grain crops.

Lime generally is needed on this soil. The response to small amounts of a complete fertilizer is fairly good, but larger amounts are not beneficial on these droughty soils.

Capability unit IIIw-1

This capability unit consists of nearly level, very poorly drained soils. It is made up of Alluvial land and of soils of the Humeston and Wabash series. These soils are on bottom lands and on low benches. The surface layer of the Humeston and Wabash soils is friable to firm or firm silt loam to silty clay. The subsoil is silty clay and clay. Alluvial land consists mainly of silt and sand mixed with clayey material.

In the Humeston and Wabash soils, the supply of organic matter generally is high. Fertility also is high. The surface soil is sticky when wet and in many places is hard and cloddy when dry. In summer cracks several feet deep develop as the soil dries. The subsoil is very slowly permeable and retards downward movement of water. In many places Humeston soils occupy small depressions in which water ponds after a rain.

The soil material making up Alluvial land is extremely variable, particularly in the lower part. Many of the areas have a growth of scrubby trees and underbrush on them. Some of the areas are cut by old meanders, oxbows, and channels that are filled with water. These areas cannot be crossed with farm machinery. Alluvial land is subject to flooding and has little value for farming unless cleared and drained.

On all soils in this unit, runoff is very slow and aeration is poor. These soils are difficult to manage. In spring they are cold and warm up slowly, and they therefore should not be worked too early. The fluctuating water table is near the surface when rainfall is above normal. Some areas are subject to flooding because of overflow from nearby streams or because of runoff from the uplands. The wetness lowers productivity, and in many places weeds are difficult to control in wet years.

If these soils are adequately drained and protected from flooding, they are suitable for cultivated crops. Soybeans and wheat are grown in many areas. Undrained areas are suited to pasture.

Fall plowing subjects these soils to freezing and thawing, and this improves their workability somewhat. If these soils are grazed when wet, they become compact and water stands in the hoofprints and injures the forage. Drainage can be improved by use of surface drains and open ditches and by use of dikes and diversions to divert runoff. Land leveling is satisfactory in some areas for improving surface drainage. It seldom is practical to use tile for drainage because permeability of the subsoil is restricted and tile drains do not function well.

Using a cropping system that includes 1 year of small grain and a green-manure crop, or 1 year of meadow, is a way of maintaining tilth and also helps in controlling weeds and insects. Plowing under crop residues also helps to maintain tilth. In places it is difficult to establish alfalfa in wet years. Where drainage is poor, alfalfa is likely to winterkill.

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Lime is needed in places on these soils for good plant growth. Corn that is not preceded by a green-manure crop generally needs nitrogen, and oats respond to nitrogen and phosphate. Potash seldom is needed in large amounts.

Capability unit IVe-1

Soils in this capability unit are moderately dark colored to dark colored, are strongly sloping or moderately steep, and are well drained to somewhat poorly drained. These soils are in the Adair, Gara, Ladoga, Marshall, Sharpsburg, and Shelby series. They are in the uplands on loess or on glacial till. Some of them are moderately eroded or severely eroded. The surface layer is friable or is friable to firm and ranges from loam to silty clay loam in texture. Adair soils have a fine-textured subsoil, but all of the other soils in this unit have a moderately fine textured subsoil.

The severely eroded soils in this unit and all of the Adair, Gara, and Shelby soils are in poor tilth, but the rest of the soils are in good tilth. Runoff is rapid, and all of the soils are subject to severe sheet and gully erosion. In many places at the upper edges of areas of Gara and Shelby soils and of the Shelby-Adair complexes, wetness is a problem in wet seasons. The Adair, Gara, and Shelby soils and the severely eroded Marshall and Sharpsburg soils are likely to puddle if worked when wet and to become cloddy and hard when dry.

The moderately steep and severely eroded soils in this unit are poorly suited to cultivated crops because of irregular slopes and low productivity. They are better suited to semipermanent or permanent hay or pasture. Growing of corn should be done only when reseeding forage crops or when renovating a pasture. Areas of Gara and Ladoga soils generally have trees and grass scattered over them, and they provide fairly good forage if not overgrazed.

Mixtures of grasses and legumes are suitable for semipermanent hay or pasture. If a good stand of these is established, the pasture should not be plowed under until the legume in the stand becomes poor, which probably would be 4 or more years after seeding. Permanent pastures can be renovated by seeding suitable legumes to supplement the bluegrass.

If protected by terraces, the strongly sloping, slightly eroded or moderately eroded Gara soils and soils of the Shelby-Adair complexes can be used for row crops more often than other soils in this unit. A suitable cropping system is 1 year each of a row crop and a small grain and 3 years of meadow.

Terraces are needed if row crops are grown, but they are hard to establish in some areas because of irregular slopes and because the sides of hills are cut by gullies. Placing terraces upslope in soils better suited to terraces helps to control losses of soil and water in these areas. In some areas of Gara and Shelby soils and of Shelby-Adair complexes seepage spots occur, but their wetness can be reduced by placing interceptor tile upslope. All gullies in these soils ought to be filled, shaped, and kept under a cover of grass.

On all of these soils, lime generally is needed. Mixtures of grasses and legumes respond well if a topdressing of lime and phosphate is applied. Pastures that are mainly in grass respond if nitrogen and phosphate are added. Potash is seldom needed in large amounts on the Ladoga, Marshall, and Sharpsburg soils, but the Adair, Gara, and Shelby soils are likely to need potash.

Capability unit IVe–2

In this unit are dark colored or moderately dark colored, moderately sloping or strongly sloping soils that are somewhat poorly drained to very poorly drained. These soils are in the Adair and Clarinda series and are on glacial till. Some of the soils are moderately eroded, and some others are severely eroded. The surface layer is friable to firm and ranges from clay loam to silty clay loam in texture.

The content of organic matter in these soils is low to medium, and tilth is poor. Permeability of the subsoil is very slow, and the available moisture holding capacity is quite high. These soils are slow to warm in spring and generally are seepy and wet at the place where they come into contact with soils on loess. They are especially wet in periods when rainfall is above normal or after frost goes out of the ground. The Clarinda soils have a sticky, clayey surface layer that is difficult to work, and some areas are gullied and have poor productivity.

Terraces are difficult to establish in these soils because slopes are irregular and many areas are gullied. Also, where subsoil material is exposed, it is difficult to establish vegetation in the terrace channels. These soils can be effectively protected from runoff and erosion by placing terraces above and below them.

These soils are poorly suited to row crops. They are suited to mixtures of grasses and legumes commonly grown in the county. Some areas are likely to be too wet for alfalfa, and other legumes more tolerant of wetness are better for areas of these soils. The pastures benefit if weeds are clipped.

Legumes and grasses on these soils respond well if lime and phosphate are added. Topdressing permanent pastures with nitrogen and phosphate increases production of forage.

Capability unit IVw–1

The soils in this capability unit are dark colored, moderately sloping, and very poorly drained. They are in the Clarinda series, in the uplands on glacial till. They are on slopes just below the loessal soils on the flats and divides. The surface soil is silty clay loam. It is friable to firm when moist and is sticky when wet. The subsoil is silty clay or clay.

These soils have medium to low content of organic matter, low fertility, and high available moisture capacity. Permeability of the subsoil is very slow. These soils are difficult to work when wet and warm up slowly in spring. The movement of air and water in the soils is restricted. If these soils are tilled too early in spring, they puddle and become hard and cloddy as they dry. In many places deep cracks develop during summer. These soils generally are seepy and wet in spring or after periods of above normal rainfall. They also are subject to erosion.

The soils in this unit are poorly suited to cultivated crops. They are better suited to hay or pasture or to other permanent vegetation. If feasible, they should be used separately or along with other similar soils for these purposes. Most areas that are in cultivated crops are small and are surrounded by soils more suitable for cultivation. In many places corn on these soils turns yellow and is stunted. Grasses and legumes that last for a long time provide a desirable cover.

The grasses and legumes commonly grown in the county are suitable for these soils. Some areas are too wet for alfalfa, and other legumes more tolerant of wetness are better suited to these areas. The clayey surface soil makes it difficult to establish a good stand of plants.

Because of the very slowly permeable subsoil, tile is not suitable for drainage. Placing interceptor tile upslope in adjacent soils, however, reduces wetness. The soils are not suited to terracing, but protection from erosion can be provided by constructing terraces upslope in soils better suited to terraces. Any gullies in the areas need to be shaped and seeded to grass. All tillage must be done on the contour.

Corn should be grown only when renovating permanent pasture or when re-establishing a stand of hay or pasture. The corn should be followed by small grain and the areas then seeded to hay or pasture. Mowing the permanent pasture helps to control weeds and also increases productivity.

The response of corn on this soil generally is low. Grasses and legumes respond favorably if lime and phosphate are added. The carrying capacity of bluegrass pasture can be increased by topdressing the areas with nitrogen and phosphate.

Capability unit Vw–1

Nodaway silt loam, channeled, is the only soil in this capability unit. It is a nearly level, moderately well drained to somewhat poorly drained soil on bottom lands. Except that the areas are cut by old oxbows and channels of meandering streams, this soil is similar to the soils in capability unit I–2. Many of the channels are filled with standing water and silt and sand. Some of the areas have a cover of scrubby trees and undergrowth.

Some areas of this soil have good potential for cultivated crops, but permanent pasture generally is the most suitable use. If streambanks are straightened to reduce flooding, and if artificial drainage is provided and timber and undergrowth are removed, this soil can be used intensively for crops. Then it can be used and managed the same as soils in capability unit I–2.

Areas of this soil that are left undrained and uncleared are suitable for pastures. Many of the pastures can be improved by mowing and by removing the brush and small trees. The trees generally have little commercial value. Bluegrass is predominant in the pastures. Reed canarygrass is suitable for wet and silted areas or for places where water stands for many days. This grass is long lived, provides a long grazing season, and produces forage that is nutritious and palatable.

Many areas of this soil could be improved for wildlife, and many old undrained bayous are desirable habitats. Food and cover for birds and small animals generally are available.

Capability unit VIe–1

This capability unit consists of moderately steep or steep, well-drained to somewhat poorly drained soils. These soils are in the Gara, Ladoga, Sharpsburg, and Shelby series. They are in the uplands on loess and glacial till. Some of the soils are severely eroded, and some others are moderately eroded. The soils in this unit are variable, but the surface layer is mostly moderately dark colored, friable or friable to firm loam to silty clay loam. The subsoil is moderately fine textured.

The content of organic matter is about medium, except in the severely eroded soils, where it is very low to low. Permeability of the subsoil is moderate to moderately slow. Runoff is rapid, but the available moisture capacity is fairly high. All of these soils are subject to sheet and gully erosion, and some areas are gullied.

Most areas of these soils are in pasture. Many of the pastures have been invaded by brush, and their productivity is low. In many places the Gara and Ladoga soils have a cover of scattered trees and grasses and occupy areas large enough to be managed separately. The trees are of poor quality and have little commercial value.

Steep slopes, low productivity, and the hazard of severe erosion make the soils in this unit poorly suited to cultivation. Pasture and meadow are a good use.

Pastures on these soils need to be improved through renovation or by seeding mixtures of more productive grasses and legumes. If the slopes are not too gullied or irregular, the existing plants can be removed in most areas by contour tillage and a seedbed prepared. In renovated pastures oats generally are grown as a cover crop because they can be pastured lightly the first year. In meadows a good aftermath should be maintained each fall to protect the soil from erosion in winter and early in spring. Grazing ought to be controlled.

Many areas of unimproved timber are grazed, but the carrying capacity of these areas is moderate to low. If such areas are needed for pasture, the trees and underbrush should be removed. Then mixtures of grasses and legumes can be seeded more easily, and the growth of the plants will not be hindered by shade from the trees.

On these soils lime generally is needed. Pastures that do not contain legumes respond if nitrogen and phosphate are applied.

Capability unit VIe-2

In this capability unit are moderately dark colored, moderately sloping to moderately steep soils that are somewhat poorly drained to very poorly drained. These soils are in the Adair, Clarinda, and Shelby series. They are on glacial till and are moderately eroded or severely eroded. The surface layer is friable to firm and ranges from light clay loam to clay in texture. The subsoil is clayey and is exposed in many places.

The content of organic matter in these soils is low, and tilth is poor. The available moisture capacity is good, but the amount of available moisture is limited because runoff is rapid. These soils generally are seepy and wet in spring, but the Shelby-Adair complexes are not so wet as the other soils in this group. The severely eroded Clarinda soils are very difficult to manage.

Steep slopes and the hazard of erosion make these soils unsuitable for cultivation. Excess moisture is also a problem in most places. These soils are hard to work, and it is difficult to prepare a seedbed in them. Consequently, hay and pasture are a better use than grain. Alfalfa is not well suited to these soils, but it can be grown on the drier areas. Legumes more tolerant to wetness are better suited to these soils. Small areas left idle are used chiefly as habitats for wildlife.

Cultivation of these soils should be done only when reseeding or renovating a pasture or meadow. Pastured areas in unproductive grasses that have been invaded by brush can be cleared and made productive if they are suitable for reseeding and renovation. Seedings of legumes and grasses are difficult to establish in some places because these soils are wet and are in poor tilth. Grazing must be controlled until seedings are well established. Gullies that have formed in the areas need to be filled and kept under sod for use as waterways.

Capability unit VIs-1

This capability unit consists only of Hagener soils, 9 to 18 percent slopes, moderately eroded. These soils are strongly sloping to moderately steep and are excessively drained. They generally occupy small areas in the uplands. The surface layer is very friable. It is variable in texture but is sandy loam in many places. The subsoil is loamy sand or loamy fine sand.

The content of organic matter is high in these soils. Permeability of the subsoil is rapid. The available moisture holding capacity is low, and these soils are very droughty. These soils are easy to work, but they dry out rapidly. If cultivated, these soils are subject to water erosion, and blowing of the sandy material may damage young plants.

These soils are not suited to row crops. Even if the areas occur with soils better suited to cultivation, it is best to leave them in hay or pasture. Oats can be grown as a nurse crop on these soils when seeding mixtures of grasses and legumes, and the crop can be grazed lightly the first year.

Leaving all crop residues on the surface increases the water-holding capacity of these soils and provides protection from wind and water erosion. Placing terraces above these soils further reduces the hazard of erosion. Terraces generally are not built in these soils, however, because they are difficult to maintain. Adding strawy material to these soils increases the fertility and the content of organic matter and also helps to control erosion. If grazing is controlled, production of forage is fairly good when rainfall is normal or above normal.

On these soils new seedings respond well if lime and phosphate fertilizer are applied. Topdressing bluegrass pastures with nitrogen and phosphate helps to promote growth of the plants and also replaces nutrients lost through leaching and through removal of forage.

Capability unit VIIe-1

This capability unit consists of moderately steep to very steep, moderately well drained and somewhat poorly drained soils. It is made up of Adair, Gara, and Shelby soils and of Sandstone rock land. In the Adair, Gara, and Shelby soils, the surface layer is variable and the subsoil is clay loam to clay or silty clay in texture. These soils overlie glacial till. Sandstone rock land is very sandy throughout and overlies sandstone.

In the Adair, Gara, and Shelby soils, fertility and content of organic matter are low and permeability of the subsoil is moderately slow to very slow. The available moisture capacity is high, but runoff is rapid and only a small amount of water enters the soil. Many areas of these soils are cut by gullies.

Sandstone rock land is low in fertility and organic matter and holds only a small amount of water for plant use. It is severely eroded and gullied.

In many places steep slopes, gullies, or rocks make it impractical to work these soils with farm implements. Improving pasture is difficult, and in many areas it is not worthwhile. Pasture on the moderately steep soils can be improved in some places by removing the trees and undergrowth and then seeding perennial grasses and legumes that last a long time. These areas will erode unless grazing is controlled and a protective cover is provided throughout the year.

Most areas in this unit have a cover of grasses and scattered trees and undergrowth. The trees are of poor quality and have no commercial value but provide some protection from erosion. The areas can be used as habitats for wildlife.

Capability unit VIIw-1

Only the land type, Marsh, is in this capability unit. It consists of very wet areas or of areas that are under water for most of the year. The areas are scattered throughout the county.

Marsh has no value for farming. The areas generally are in low places and lack suitable outlets for drainage. They could be reclaimed for pasture or cultivated crops if the level of water in the areas could be controlled.

At present Marsh is best suited for use as wildlife habitats. Willows, cattails, and other plants that tolerate wetness grow well in the marshy areas. Waterfowl, muskrats, and upland game find cover, food, and nesting places in and around the areas.

Soil Productivity

An estimate of expected yields should be made before the cropping system is planned for a soil. Table 2 lists predicted acre yields of the principal crops on each soil in the county if the soil has been managed well for 10 years or more. A high level of management includes the following practices:

1. Controlling erosion.
2. Providing adequate drainage for wet soils.
3. Applying fertilizer and lime in the kinds and amounts indicated by soil tests so that the soil reaches levels of fertilization and reaction of those suggested by the testing laboratory of Iowa State University.
4. Planting corn in amounts that will produce a plant population no greater than the available moisture will support.
5. Using cropping systems suggested in the subsection "Management by Capability Units."
6. Planting suitable varieties of crops.
7. Controlling weeds, plant diseases, and insects effectively.
8. Cultivating and harvesting at the proper time.
9. Controlling floods.
10. Planting alfalfa or mixtures of alfalfa and bromegrass for hay on suitable soils and, in three cuttings the first year, obtaining yields listed in table 2.

The average yields in table 2 are considered to be fairly reliable appraisals of what can be harvested if a high level of management is applied. They are based on research data from experimental farms, on the experience of farmers, on the judgment of soil scientists, and on the opinion of the agronomy staff at Iowa State University. Yields fluctuate from year to year. A few farmers who use the best techniques and management known today may exceed the estimated yields by as much as about 10 percent. The averages may be changed in the future by the introduction of new crop varieties, by better fertilization practices, or by other improved methods.

TABLE 2.—*Predicted acre yields of the soils under a high level of management*

[Dashes indicate that the crop is not suited to the soil or is not generally grown on it]

Soil	Corn	Soybeans	Oats	Hay	Pasture
	Bu. per acre	*Bu. per acre*	*Bu. per acre*	*Tons per acre*	*Animal-unit-days* [1]
Adair clay loam, 5 to 9 percent slopes, moderately eroded	55	--------	41	1.5	75
Adair clay loam, 9 to 14 percent slopes	45	--------	33	1.4	70
Adair clay loam, 9 to 14 percent slopes, moderately eroded	40	--------	30	1.0	50
Adair clay loam, 14 to 18 percent slopes, moderately eroded	--------	--------	--------	.8	40
Adair soils, 5 to 9 percent slopes, severely eroded	40	--------	30	1.0	50
Adair and Shelby soils, 9 to 14 percent slopes, severely eroded	--------	--------	--------	.6	30
Adair and Shelby soils, 14 to 18 percent slopes, severely eroded	--------	--------	--------	.5	25
Alluvial land	(2)	(2)	(2)	1.5	75
Ankeny fine sandy loam	62	30	47	2.5	125
Bremer silty clay loam	70	34	52	3.5	175
Calco silty clay loam	82	32	61	3.5	175
Clarinda silty clay loam, 5 to 9 percent slopes	50	--------	36	1.6	80
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	45	--------	34	1.5	70
Clarinda silty clay loam, 9 to 14 percent slopes	35	--------	26	1.2	60
Clarinda silty clay loam, 9 to 14 percent slopes, moderately eroded	30	--------	22	1.0	50
Clarinda soils, 5 to 18 percent slopes, severely eroded	--------	--------	--------	1.0	50
Colo silty clay loam	85	35	64	3.5	175
Colo silt loam, overwash	86	36	65	3.5	175
Colo-Nodaway complex	80	31	60	3.5	175
Corley silt loam, 0 to 2 percent slopes	75	30	52	3.5	175
Gara loam, 9 to 14 percent slopes	60	--------	46	2.5	125
Gara loam, 9 to 14 percent slopes, moderately eroded	58	--------	42	2.5	125
Gara loam, 14 to 18 percent slopes	--------	--------	--------	2.2	110
Gara loam, 14 to 18 percent slopes, moderately eroded	--------	--------	--------	2.0	100

See footnotes at end of table.

TABLE 2.—*Predicted acre yields of the soils under a high level of management*—Continued

Soil	Corn	Soybeans	Oats	Hay	Pasture
	Bu. per acre	*Bu. per acre*	*Bu. per acre*	*Tons per acre*	*Animal-unit-days* [1]
Gara loam, 18 to 25 percent slopes, moderately eroded				1.5	75
Gara soils, 14 to 18 percent slopes, severely eroded				1.5	75
Hagener soils, 9 to 18 percent slopes, moderately eroded				1.2	60
Humeston silt loam	65	25	49	2.2	110
Judson silt loam, 0 to 2 percent slopes	90	35	67	4.0	200
Judson silt loam, 2 to 5 percent slopes	88	35	67	3.5	175
Judson silt loam, 5 to 9 percent slopes	83	30	62	3.3	165
Judson-Colo complex, 2 to 5 percent slopes	78	28	56	3.3	165
Kennebec silt loam	90	35	67	3.5	175
Ladoga silt loam, 2 to 5 percent slopes	84	30	63	3.8	190
Ladoga silt loam, 5 to 9 percent slopes	80	25	61	3.6	180
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	76	24	56	3.6	180
Ladoga silt loam, 9 to 14 percent slopes	72		52	3.4	170
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	68		48	3.4	170
Ladoga soils, 9 to 14 percent slopes, severely eroded	62		44	3.0	150
Ladoga silt loam, 14 to 18 percent slopes	63		45	3.2	160
Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	60		42	3.0	150
Ladoga silt loam, benches, 2 to 5 percent slopes	84	30	63	3.8	190
Ladoga soils, 14 to 18 percent slopes, severely eroded				2.8	140
Marsh					
Marshall silty clay loam, 0 to 2 percent slopes	90	35	67	4.0	200
Marshall silty clay loam, 2 to 5 percent slopes	88	35	66	3.8	190
Marshall silty clay loam, 5 to 9 percent slopes	85	32	64	3.5	175
Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	80	28	60	3.4	175
Marshall silty clay loam, 5 to 9 percent slopes, severely eroded	74	24	54	3.0	150
Marshall silty clay loam, 9 to 14 percent slopes	76		56	3.4	170
Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	72		52	3.4	170
Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	68		50	2.8	140
Marshall silty clay loam, 14 to 18 percent slopes, moderately eroded	62		45	2.5	25
Marshall silty clay loam, 14 to 18 percent slopes, severely eroded	58		41	2.0	100
Marshall silty clay loam, benches, 0 to 2 percent slopes	90	35	67	4.0	200
Marshall silty clay loam, benches, 2 to 5 percent slopes	88	35	66	4.0	200
Marshall silty clay loam, benches, 5 to 9 percent slopes, moderately eroded	80	25	60	4.0	200
Minden silty clay loam, benches	90	35	67	3.8	190
Nevin silty clay loam	90	35	67	3.5	175
Nodaway silt loam	88	35	67	3.5	175
Nodaway silt loam, channeled				2.0	100
Olmitz loam, 2 to 5 percent slopes	80	35	60	4.0	200
Sandstone rock land					
Sharpsburg silty clay loam, 0 to 2 percent slopes	90	35	67	4.0	200
Sharpsburg silty clay loam, 2 to 5 percent slopes	85	35	64	4.0	200
Sharpsburg silty clay loam, 5 to 9 percent slopes	82	32	62	3.8	190
Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	78	28	58	3.6	180
Sharpsburg silty clay loam, 9 to 14 percent slopes	74		54	3.4	170
Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	70		50	3.4	170
Sharpsburg silty clay loam, 9 to 14 percent slopes, severely eroded	65		48	2.5	125
Sharpsburg silty clay loam, 14 to 18 percent slopes, moderately eroded	60		44	2.5	125
Sharpsburg silty clay loam, 14 to 18 percent slopes, severely eroded				2.0	100
Shelby loam, 5 to 9 percent slopes, moderately eroded	70	25	52	3.0	150
Shelby loam, 9 to 14 percent slopes	62		46	2.7	135
Shelby loam, 9 to 14 percent slopes, moderately eroded	60		44	2.5	125
Shelby soils, 9 to 14 percent slopes, severely eroded	50		37	2.5	125
Shelby loam, 14 to 18 percent slopes	50		37	2.3	115
Shelby loam, 14 to 18 percent slopes, moderately eroded	48		35	2.0	100
Shelby soils, 14 to 18 percent slopes, severely eroded				2.0	100
Shelby loam, 18 to 25 percent slopes, moderately eroded				1.5	60
Shelby soils, 18 to 30 percent slopes, severely eroded				1.0	50
Shelby-Adair complex, 5 to 9 percent slopes, moderately eroded	62	21	47	2.5	125
Shelby-Adair complex, 9 to 14 percent slopes	50		37	2.3	115
Shelby-Adair complex, 9 to 14 percent slopes, moderately eroded	47		35	2.0	100
Shelby-Adair complex, 14 to 18 percent slopes, moderately eroded				1.6	80
Shelby-Adair complex, 18 to 25 percent slopes, moderately eroded				1.4	70
Shelby-Adair complex, 18 to 30 percent slopes, severely eroded				.6	30
Wabash silty clay	55	24	[3] 22	3.0	150
Wabash silty clay loam	60	25	[3] 20	3.0	150
Zook silty clay loam	68	34	50	3.0	150
Zook silt loam, overwash	70	35	52	2.7	135

[1] A term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single grazing season without injury to the sod. An acre of pasture that provides 30 days of grazing for two cows has a carrying capacity of 60 animal-unit-days.

[2] Variable.

[3] Bushels of wheat.

Wildlife

Cass County supports many kinds of wildlife that contribute to the economy of the county and that have recreational value. The kinds and numbers of wildlife that can be produced and maintained in the county are largely determined by the kinds and amounts of vegetation the soils can produce and by the way the vegetation is distributed.

Wildlife is influenced by topography and by such soil characteristics as fertility. Fertile soils are capable of greater wildlife production than less fertile soils. Topography affects wildlife through its influence on land use. Extremely rough, irregular areas may be hazardous to livestock and be unsuitable for crops, but the undisturbed vegetation is often valuable to wildlife. If suitable vegetation is lacking in such areas, it can often be developed to improve conditions for desirable kinds of wildlife.

Wetness and water-holding capacity of the soils are important in selecting soils for constructing ponds for fish and in developing and maintaining habitats for waterfowl. Marsh areas can be developed to provide aquatic or semiaquatic habitats for waterfowl and for some furbearers.

The soils of Cass County produce suitable habitats for a number of wildlife species. The nearly level and gently sloping soils, however, generally are cropped intensively and provide only limited shelter and nesting areas for wildlife. Much of the wildlife is on the moderately sloping to steep Gara, Ladoga, Marshall, Sharpsburg, and Shelby soils in the uplands. Here pheasants, which were introduced into the county some time ago, are most numerous. Fox, squirrel, woodchuck, and cottontail rabbit also generally are abundant in the uplands. White-tailed deer frequent soil association 6 and soils adjacent to this association. Muskrat, mink, and other furbearing animals frequent the rivers and creeks throughout the county. They probably are most numerous in soil association 6, but they occur along all of the watercourses. Fish are abundant in the rivers and creeks of the county. Farm ponds provide excellent fishing if well managed.

The wildlife resources of the county are important primarily for the opportunities they provide for recreation. Many species of wildlife, however, such as songbirds, hawks, owls, snakes, and other predators, are also beneficial in the control of rodents and undesirable insects.

The combination of soils, topography, and vegetation in the county favors the development of facilities for recreation. Soils in associations 2, 4, and 5 provide the most opportunities because many of the sites have potential for ponds. Many areas that are wet or otherwise have little value for farming could be developed for recreation. Cold Springs State Park, south of the town of Lewis, is an example of such a development (fig. 10).

Increased travel by the American public also provides opportunities for using suitable soils for recreational purposes. Some areas along main highways are suitable sites for overnight camping facilities or for use as picnic areas. These would be a real convenience to travelers and an additional source of income for landowners.

Although there are many areas in the county suitable for wildlife, many more could be developed and recreational benefits thus increased. The soils of any capability class will support good wildlife habitats if properly used. Small, odd-shaped areas of little value for other purposes can be developed to encourage wildlife. Suitable for such a purpose are many areas of Sandstone rock land, of moderately steep or steep Adair, Gara, and Shelby soils, and of soils of the Shelby-Adair complexes.

Woodland

About 9,000 acres in Cass County is wooded (*5*). Most of the woodland borders the East Nishnabotna and West Nodaway Rivers and their larger tributaries. A few farms have small woodlots, and most farmsteads have landscape and windbreak plantings of trees and shrubs.

Most wooded areas are grazed and produce little merchantable timber. Steep woodland areas generally are left untouched. Woodland that adjoins pasture is little more than a source of shade for livestock or a habitat for wildlife.

The acreage of woodland in the county has not changed significantly in recent years. Some areas have been converted to cropland, and most of these converted areas are along stream bottoms. The woodlots and buildings on many vacant farmsteads have been removed and the areas used for crops.

The farmers in Cass County are concerned chiefly with the planting of trees for windbreaks rather than for production of timber. The demand for trees for lumber is small, and the quality of the timber that is produced is poor. Several agencies in Iowa can assist woodland owners in improving their products and marketing them. The Soil Conservation Service can help woodland owners in determining which soils are suitable for trees. State foresters can assist in developing plans for managing new or old stands of trees. The types of woodland in the county and the suitability of the soils for planting various kinds of trees are discussed in the paragraphs that follow.

Types of woodland

Two types of woodland occur in Cass County. They are the oak-hickory type and the soft maple-elm-cottonwood type.

The oak-hickory type is in the rolling uplands. The areas are chiefly near the major streams, where the Gara and Ladoga soils predominate. These soils are deep, are gently sloping to steep, and have an average supply of moisture. Besides the predominant oak and hickory, the stands include elm, basswood, hackberry, and green ash.

The soft maple-elm-cottonwood type is on nearly level bottom lands and low benches. Here Alluvial land and the Kennebec and Nodaway soils predominate. Besides the predominant elm, soft maple, and cottonwood, the stands include willow, various kinds of oak, hickory, green ash, and black-walnut. The willow and cottonwood trees generally are near streams in areas that are most subject to overflow and prolonged wetness.

Landscape and windbreak plantings have been established in the county since the time of settlement. These plantings include spruce and various kinds of pine and fir.

Planting suitability groups

The soils in Cass County have been placed in three groups according to their suitability for planting trees. The soil series in each group are given, the soil characteristics that affect the growth of trees are stated, and the trees suitable for planting are listed. The lists include species suitable for timber, windbreaks, and Christmas trees, as

Figure 10.—**Fishing in the cool waters of Cold Springs State Park.**

well as trees and shrubs for wildlife food and cover. Local and State publications can be consulted to learn which trees are most suitable for specific uses.

In general, hardwoods grow poorly on fields that have been in cultivation a long time, where the soils are eroded and depleted. For such sites, pines are better suited. Wildlife plantings should include trees that provide both food and cover. Soils that are flooded regularly are not suitable for planting trees and shrubs for wildlife.

PLANTING SUITABILITY GROUP 1

This planting suitability group consists mainly of soils in the rolling uplands, but a few of the soils are on low benches and foot slopes. These soils are the most favorable in the county for trees. They are in the Adair, Clarinda, Gara, Judson, Kennebec, Ladoga, Marshall, Minden, Nevin, Olmitz, Sharpsburg, and Shelby series. Slopes are mainly 0 to 14 percent, though slopes that face north and east are more than 14 percent.

Most soils in this group are deep. Permeability is moderate to moderately slow in all but the Adair and Clarinda soils. The Adair and Clarinda soils are fine textured and very slowly permeable and are seepy and wet in many places.

Suitable trees for planting on most of the soils are eastern redcedar, Austrian pine, Douglas-fir, European larch, ponderosa pine, Scotch pine, black walnut, green ash, hackberry, and cottonwood. Only eastern redcedar, Scotch pine, green ash, cottonwood, and hackberry are suitable for planting on the Adair and Clarinda soils. Black walnut is better suited to the Judson and Kennebec soils than to the other soils in this group.

Trees and shrubs suitable for wildlife food and cover on most of the soils are dogwood, honeysuckle, nannyberry, ninebark, Asiatic trailing raspberry, eastern redcedar, Russian-olive, multiflora rose, and wild plum. On the Adair and Clarinda soils, however, only dogwood, honeysuckle, and eastern redcedar are suitable for this purpose.

PLANTING SUITABILITY GROUP 2

Soils in this group are similar in depth and permeability to those in planting suitability group 1. They are in the rolling uplands and are in the Ankeny, Gara, Hagener, Ladoga, Marshall, Sharpsburg, and Shelby series. Sandstone rock land is also in the group. The sites are mostly on south- and west-facing slopes that exceed 14 percent. A few sandy soils, some of which are less sloping, are included.

Trees suitable for planting on the soils in this group are eastern redcedar, ponderosa pine, Douglas-fir, Scotch pine, European larch, Austrian pine, hackberry, cottonwood, and green ash.

Shrubs and trees suitable for wildlife cover and food on most of the soils are Asiatic trailing raspberry, chokecherry, hazlenut, honeysuckle, mulberry, multiflora rose, nannyberry, ninebark, eastern redcedar, Russian-olive, and wild plum. Only honeysuckle, eastern redcedar, Russian-olive, and wild plum, however, are suitable for planting for wildlife on the Ankeny and Hagener soils and on Sandstone rock land.

PLANTING SUITABILITY GROUP 3

The soils in this group are nearly level and are on bottom lands and low benches. They consist of Bremer, Calco, Colo, Corley, Humeston, Nodaway, Wabash, and Zook soils and of Alluvial land. These soils vary widely in texture and in permeability. They all receive excess water because of overflow or runoff.

Suitable trees for planting on the soils in this group are cottonwood, hackberry, green ash, and soft maple. A suitable shrub to plant for wildlife food and cover is honeysuckle.

Engineering Properties of Soils

Engineers have studied soil characteristics that affect construction and have devised systems of soil classification based on these characteristics. Most of these studies, however, have been at the site of construction, and for this reason, general information about the engineering properties of soils has not been readily available. Such information is made available in this section. Engineers can use it to—

1. Make studies of soil and land use that will aid in selecting and developing sites for industries, businesses, residences, and recreational areas.
2. Assist in planning and designing erosion and flood control structures, drainage improvements, and other structures for soil and water conservation.
3. Make reconnaissance surveys of soil and ground conditions that will aid in selecting locations for highways and airports and in planning more detailed soil surveys for the intended locations.
4. Locate probable sources of sand and gravel for use in structures.
5. Correlate pavement performance with soil mapping units, and thus develop information that will be useful in designing and maintaining pavements.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and from aerial photographs.

It should be emphasized that the interpretations made in this soil survey are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads or at a site where excavations are to be deeper than the depths of the layers here reported. Also, engineers should not apply specific values to the estimates for bearing capacity given in this survey. Nevertheless, by using this survey, an engineer can select and concentrate on those soil units most important for this proposed kind of construction, and in this manner reduce the number of soil samples taken for laboratory testing and complete an adequate soil investigation at minimum cost.

Some of the terms used by agricultural soil scientists may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, and sand—may have special meanings in soil science. These and other special terms used in the soil survey are defined in the Glossary in the back of this survey.

Engineering Classification Systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (AASHO) (*1*). In this system soil materials are classified in seven principal groups. The groups range from A–1, consisting of gravelly soils having high bearing capacity, to A–7, which is made up of clayey soils having low strength when wet.

Some engineers prefer to use the Unified soil classification system (*30*). In this system soil materials are identified as coarse grained (8 classes), fine grained (6 classes), or highly organic. An approximate classification can be made in the field. Estimated classifications of the soils in Cass County under both systems are given in table 3.

Soil Engineering Data and Interpretations

Information and interpretation of most significance to engineers are given in tables 3, 4, and 5. The data in table 3 are based on the test data in table 5, on information in other parts of the survey, and on experience with similar soils in other counties. Table 5 presents laboratory test data for samples taken from selected soil profiles in Cass County. Additional information can be obtained from other parts of the survey, especially from the sections "General Soil Map," "Descriptions of the Soils," and "Formation and Classification of Soils."

The percentage passing sieves, shown in table 3, is the normal range of soil particles passing the respective screen sizes.

Permeability refers to the rate of movement of water through the undisturbed soil. Permeability depends largely on the soil texture and structure.

Available water capacity is the amount of water in a moist soil, at field capacity, that can be removed by plants. These ratings, expressed in inches of water per inch of soil depth, are of particular value to engineers engaged in irrigation.

Shrink-swell potential is a rating of the ability of soil material to change volume when subjected to changes in moisture. These soil materials rated high are normally undesirable from the engineering standpoint, since the increase in volume when the dry soil is moistened generally is accompanied by a loss in bearing capacity. In general, soils classed as CH and A–7 have high shrink-swell potential. Clean sands and gravels (single-grain structure) and soils containing a small amount of nonplastic to slightly plastic fines have low shrink-swell potential.

Interpretations of engineering properties of the soils are given in table 4. In this table are estimates of the suitability of the soils of the county as a source of topsoil and roadfill. Also in the table are estimates of soil features affecting suitability of the soils for various engineering purposes.

Soil Features Affecting Highway Work [3]

Many of the soils of Cass County formed in loess that overlies glacial till of Kansan age. The loess ranges from more than 20 feet in thickness on the nearly level uplands and tops of ridges to a thin layer in the more sloping areas. Soils that formed in glacial till are in the more sloping areas where the glacial till has been exposed.

The Minden soils are examples of soils derived from a thick layer of loess in nearly level areas. These soils are fine textured and are classified A–7 (ML–CL). They generally have moderately high group index numbers. Minden soils contain organic matter to a depth of a foot or more and are difficult to compact to good density. Their subsoil is a more plastic silty clay. The more sloping Marshall and Sharpsburg soils also formed in loess. These soils have a less well developed surface layer than the more nearly level soils, and they have a less plastic subsoil. Their subsoil is classified A–6 to A–7–6 (ML–CL), and they have fairly high group index numbers. Sloping soils formed in loess erode readily if runoff is concentrated. Sodding, paving, or construction of check dams is needed in gutters and ditches for control of erosion.

In the soils derived from loess, the seasonal high water table generally is above the contact of the loess and the glacial till. In these areas the in-place density of the loess is fairly low, and the moisture content is high. This high moisture content may cause instability in embankments unless it is controlled enough to permit the soil to be compacted to high density.

Because of their high in-place density, soils derived from glacial till generally do not have an excessively high moisture content and are more easily compacted than soils derived from loess. On the nearly level to gently rolling uplands, under a mantle of loess, are the remains of the original Kansan till plain. This glacial till is heterogenous and of poor quality for engineering work. The upper layer is very plastic clay, or gumbotil, and is classified A–7–6 (19–20). This clay crops out on slopes toward drainageways, where the loess is thin, and is the parent material of the Adair and Clarinda soils. It is not stable enough to be used for highway subgrades and should not be used in fills that are within 5 feet of the finished grade. If this clay occurs at grade in roadcuts, it should be removed to a depth of 2 feet and should be replaced with a backfill of good glacial till or of granular soil.

Below the clayey layer is heterogenous Kansan till that is classified primarily A–6 (CL). This till crops out on the lower part of slopes and is the parent material of the Gara and Shelby soils. If this till occurs in or along grading projects, it generally is placed in the upper subgrade in unstable areas. Pockets and lenses of sand and gravel commonly are interspersed throughout the till and in many places are water bearing. Frost heaving is likely if the road grade is only a few feet above such deposits and if the deposits are overlain by loess or silty till. These deposits can be drained or the soil above them can be replaced with a backfill of granular material or of clayey glacial till to prevent frost heaving.

The soils of bottom lands formed in recent alluvium washed from hills and uplands. Such soils as Colo, Judson, Kennebec, and Wabash have a thick, organic surface layer that may consolidate erratically under an embankment load. Some of the soils, such as the Colo, Humeston, and Wabash, have a subsoil that is classified A–7 (CH). These soils have low in-place density and a high content of moisture. If an embankment in these soils is to be more than 15 feet high, the soils should be carefully analyzed to determine if they are strong enough to support it. Roadways through bottom lands should be constructed on a continuous embankment that extends above the flood level. The Nodaway soils, for example, contain lenses of fine sand in places. If an embankment is constructed only a few feet above the water table in such soils, frost heaving is likely unless drainage is provided or unless materials that are not susceptible to frost action are used in the subgrade.

The bedrock in Cass County consists of shale, limestone, or sandstone. Care is needed if roadways are constructed in shale areas because disturbance of the natural slopes could cause the soil above the shale to slide.

Included in table 4 are ratings that show the suitability of the soils of the county as a source of topsoil that can be used to promote the growth of vegetation on embankments and in cuts in slopes, and in ditches, and as a source of borrow for road construction. Topsoil consisting of organic material is not suitable for use on shoulders of highways that are to support limited traffic during wet periods. Ratings of the suitability of the soils as a source of sand and gravel are not shown in the table, because few areas in Cass County are suitable as sources of sand and gravel.

Conservation Engineering [4]

Engineering work for soil conservation in Cass County consists chiefly of building structures for the control of erosion and of installing systems for drainage and irrigation.

Erosion control structures

Structures for the control of erosion in Cass County consist chiefly of terraces, diversions, grassed waterways, and of structures that help to stabilize gullies and hold water. These are discussed in the paragraphs that follow. Some features that affect the suitability of the soils in the county for these uses are shown in table 4. If technical assistance is needed in installing a structure, it can be obtained from the Cass County Soil and Water Conservation District.

Terraces.—A terrace is a channel built across a slope to intercept runoff and control erosion. All terraces help to control erosion by reducing the length of slope and thus permitting more intensive cultivation of the soils without excessive loss of soil.

[3] By ROBERT E. BLATTERT, soils geologist, Iowa State Highway Commission.

[4] By VOLNEY H. SMITH, civil engineer, Soil Conservation Service.

TABLE 3.—*Estimates of soil properties*

Soil series and map symbol	Depth from surface	Classification	
		USDA texture	Unified
	Inches		
Adair (AdC2, AdD, AdD2, AdE2, ArC3, AsD3, AsE3). (For properties of Shelby soils in mapping units AsD3 and AsE3, refer to the Shelby series in this table.)	0–8	Clay loam	CL
	8–16	Clay loam	CL
	16–31	Clay	CH
	31–50	Clay loam	CL
Alluvial land (Au)[1].			
Ankeny (Ay).	0–40	Fine sandy loam	SM
Bremer (Br).	0–20	Silty clay loam	OH to CH
	20–28	Light silty clay	CH
	28–42	Silty clay loam	CL or CH
	42–60	Stratified silt and silty clay loam.	ML or CL to CH
Calco (Ca).	0–36	Silty clay loam	OL or CH
	36–50	Silty clay loam	CH
Clarinda (CdC, CdC2, CdD, CdD2, CeD3).	0–12	Silty clay loam	OH or MH, CH
	12–60	Silty clay or clay	CH
Colo (Cg, Ch, Cn). (For properties of Nodaway soil in mapping unit Cn, refer to the Nodaway series in this table.)	0–43	Silty clay loam	OL or CH
	43–51	Silty clay loam	CH
Corley (CoA).	0–31	Silt loam	CL
	31–46	Silty clay loam	CL or CH
	46–60	Silt loam	CL
Gara (GaD, GaD2, GaE, GaE2, GaF2, GrE3)	0–10	Loam	CL
	10–45	Clay loam	CL or CH
Hagener (HaD2).	0–7	Fine sandy loam	SM
	7–25	Loamy fine sand	SM
	25–60	Fine sand	SM to SP
Humeston (Hu).	0–19	Heavy silt loam	CL
	19–62	Silty clay	CH
Judson (JdA, JdB, JdC, JoB). (For properties of Colo soil in mapping unit JoB, refer to the Colo series in this table.)	0–23	Silt loam	OL or CL
	23–60	Light silty clay loam	CL
Kennebec (Ke).	0–34	Silt loam	OL or CL
	34–55	Silty clay loam	CL
Ladoga (LaB, LaC, LaC2, LaD, LaD2, LaE, LaE2, LbB, LdD3, LdE3).	0–14	Silt loam	ML
	14–50	Silty clay loam	ML or MH to CH
Marsh (Ma).	(2)	(2)	OH–ML
Marshall (MhA, MhB, MhC, MhC2, MhC3, MhD, MhD2, MhD3, MhE2, MhE3, MmA, MmB, MmC2).	0–13	Light silty clay loam	ML–CL
	13–58	Silty clay loam	ML–CL
	58–76	Silt loam	ML–CL
Minden (Mn).	0–22	Light silty clay loam	ML–CL
	22–46	Silty clay loam	ML–CL
	46–60	Silt loam	ML–CL
Nevin (Ne).	0–25	Light silty clay loam	OL–CH
	25–60	Silty clay loam	CH
Nodaway (No, Nw).	0–39	Silt loam	CL
	39–50	Silt loam	CL
Olmitz (OmB).	0–23	Loam	ML–CL
	23–54	Light clay loam	ML–CL

See footnotes at end of table.

significant in engineering

Classification—Continued	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-6(11)	100	98-100	70-90	0.2-0.8	0.18	5.6-6.0	Moderate.
A-6(11) to A-7-6(15)	100	98-100	70-85	0.2-0.8	.17	5.6-6.0	Moderate.
A-7-6(17-19)	100	98-100	65-80	<0.05	.15	5.6-6.0	High.
A-6(12) to A-7-6(15)	100	98-100	60-75	0.2-0.8	.16	5.6-6.0	Moderate.
A-4	100	100	35-50	2.5-5.0	.14	6.6-7.3	Low.
A-7-6(12) to A-7-5(17-20)	100	100	95-100	0.2-0.8	.21	6.6-7.3	High.
A-7-6(17-20)	100	100	95-100	<0.05	.18	6.6-7.3	High.
A-7-6(14-20)	100	100	95-100	0.2-0.8	.19	6.6-7.3	High.
A-6 to A-7-6	100	100	95-100	0.8-2.5 or 0.2-0.8	.19	6.6-7.3	Moderate to high.
A-7-6(14-18)	100	100	95-100	0.2-0.8	.21	7.9-8.4	High.
A-7-6(14-18)	100	100	95-100	0.2-0.8	.18	7.4-7.8	High.
A-7-6(14-18)	100	100	95-100	0.2-0.8	.18	5.6-6.0	High.
A-7-6(20)	100	100	95-100	<0.05	.16	5.6-6.0	High.
A-7-6(14-19)	100	100	95-100	0.2-0.8	.21	6.0-7.3	High.
A-7-6(14-19)	100	100	95-100	0.2-0.8	.18	6.6-7.3	High.
A-7-6(10-14)	100	100	95-100	0.8-2.5	.20	5.1-6.0	Moderate.
A-7-6(16-18)	100	100	95-100	0.2-0.8	.17	5.6-6.0	High.
A-7-6(10-14)	100	100	95-100	0.8-2.5	.18	6.1-6.5	Moderate.
A-6(8-12)	100	90-100	55-70	0.8-2.5	.19	5.6-6.0	Low to moderate.
A-6(8) to A-7-6(16)	100	90-100	55-75	0.2-0.8	.17	5.1-6.0	Moderate.
A-2 to A-4	100	100	30-50	2.5-5.0	.10	5.6-6.0	Low.
A-2-6	100	100	15-25	5.0-10.0	.06	5.6-6.0	Low.
A-2-6 to A-3	100	100	5-15	5.0-10.0	.04	5.6-6.0	Low.
A-7-6(12-16)	100	100	95-100	0.8-2.5	.20	5.1-5.5	Moderate to high.
A-7-6(20)	100	100	95-100	<0.05	.17	6.1-6.5	High.
A-6(12)	100	100	95-100	0.8-2.5	.20	5.6-6.0	Moderate.
A-7-6(14)	100	100	95-100	0.8-2.5	.18	5.6-6.0	Moderate.
A-6(12) to A-7-6(14)	100	100	95-100	0.8-2.5	.21	5.6-6.5	Moderate.
A-7-6(10-14)	100	100	95-100	0.8-2.5	.19	6.1-6.5	Moderate to high.
A-6(10)	100	100	95-100	0.8-2.5	.20	4.5-6.5	Moderate.
A-7-6(16)	100	100	95-100	0.2-0.8	.19	5.1-5.5	High.
A-7-5 to A-7-6	[2]	[2]	[2]	[1]	[1]	[2]	[2]
A-6(10) to A-7-6(15)	100	100	95-100	0.8-2.5	.21	5.6-6.0	Moderate.
A-6(10) to A-7-6(15)	100	100	95-100	0.8-2.5	.18	5.6-6.5	Moderate.
A-6(10) to A-7-6(15)	100	100	95-100	0.8-2.5	.16	6.6-7.3	Moderate.
A-6(12) to A-7-6(16)	100	100	94-100	0.5-2.0	.20	5.6-6.5	Moderate to high.
A-6(12) to A-7-6(16)	100	100	94-100	0.5-2.0	.18	5.6-6.0	Moderate to high.
A-6(12) to A-7-6(16)	100	100	94-100	0.8-2.5	.16	5.6-6.0	Moderate to high.
A-6(12) to A-7-6(14)	100	100	92-98	0.5-2.0	.20	6.1-7.3	Moderate to high.
A-7-6(13-19)	100	100	92-98	0.2-0.8	.18	6.6-7.3	High.
A-6(9) to A-7-6(12)	100	100	90-97	0.8-2.5	.20	6.1-6.5	Moderate.
A-6(9) to A-7-6(12)	100	100	95-100	0.8-2.5	.18	5.6-6.0	Moderate.
A-6(10) to A-7-6(14)	100	90-98	30-50	0.8-2.5	.18	5.6-6.0	Moderate.
A-6(10) to A-7-6(14)	100	90-98	30-50	0.5-2.0	.16	5.6-6.0	Moderate.

TABLE 3.—*Estimates of soil properties*

Soil series and map symbol	Depth from surface	Classification	
		USDA texture	Unified
	Inches		
Sandstone rock land (Sa).	0–9	Sandy loam	SM
	9–50	Fine sand and sandstone fragments.	SP
Sharpsburg (SbA, SbB, SbC, SbC2, SbD, SbD2, SbD3, SbE2, SbE3).	0–13	Silty clay loam	ML–CL
	13–50	Silty clay loam	ML–CL to CH.
Shelby (ShC2, ShD, ShD2, ShE, ShE2, ShF2, SsD3, SsE3, SsF3, SyC2, SyD, SyD2, SyE2, SyF2, SyF3). (For properties of Adair soils in mapping units SyC2 through SyF3, refer to the Adair series in this table.)	0–8	Loam	CL, CH
	8–41	Clay loam	CL, CH
	41–58	Clay loam	CL, CH
Wabash:			
Silty clay (Wa).	0–28	Silty clay	OH–CH
	28–55	Silty clay	CH
Silty clay loam (Wb).	0–13	Silty clay loam	OH–CH
	13–19	Silty clay	OH–CH
	19–80	Silty clay	CH
Zook (Zo, Zk [3]).	0–22	Silty clay loam	OH–CH
	22–65	Silty clay	CH

[1] Variable.
[2] Not determined.

The average grades on graded terraces should range between 0.3 and 0.6 percent, but these grades can be varied within safe limits to provide for a system of parallel terraces. Alinement of the terraces can be improved and the terraces kept parallel by use of cut-and-fill construction methods. If infertile subsoil is exposed when the terraces are being built, topdressing the terrace channel and cuts in slopes with barnyard manure and fertilizer is helpful.

Deep soils, such as the Marshall and Sharpsburg, allow more latitude in the choice of terrace design than shallow soils. By making deep cuts and high fills, level terraces can be run parallel to each other and point rows can be eliminated between the terraces. Bench-type, level terraces that have a seeded backslope can also be used in these soils. Such terraces provide fairly straight, level rows and more uniform distribution of moisture.

In general, initial terracing on any farm in this county ought to be on upland soils that are good for crops. Such soils are likely to be cultivated fairly intensively. Terraces in them should be made straight, and if feasible, they should be made parallel if more than one terrace is used. Terraces generally are not placed in Shelby and Adair soils. Many areas of these soils are used for pasture and hay, and terraces add little to their value for these uses. Terraces can be built on the Shelby and Adair soils, but management requirements generally are high.

Diversions.—A diversion is a channel constructed across a slope to intercept surface water and channel it to a safe outlet. Diversions can be used to protect nearly level soils on bottom lands and benches from being flooded by surface runoff from adjacent, steeper soils. They can also be used to protect sloping soils from excessive runoff from higher lying soils. Diversions should not be used as a substitute for terraces on soils used for cultivated crops. They ought to be included as an integral part of a planned terrace system. Soil is likely to be washed into channels of diversions that are not protected by terraces and greatly reduce their capacity and impair their function. The Judson, Kennebec, Marshall, Nodaway, Wabash, and Zook soils are examples of soils in this county that can be protected in places by diversions.

Grassed waterways.—A grassed waterway is a channel, covered by grass for protection against erosion, that conducts runoff water away from cropland to a stable outlet. Grassed waterways also provide outlets for graded terraces and diversions. Most of the drainageways in the uplands of the county are subject to erosion, and many miles of grassed waterways therefore are needed.

Many drainageways in the county are gullied, and large quantities of earth will have to be moved before the channels can be properly shaped. Graded waterways in this county generally function properly if designed for runoff flowing at a velocity of 4 to 5 feet per second. If the slope and cross section will not permit the design of a channel to keep the flow within these limits, structures for gully control ought to be considered.

Most of the soils of the county are fertile enough to grow suitable vegetation if the waterway has been shaped and the velocity of the water reduced. If infertile soil is exposed when the waterways are reshaped, barnyard manure, fertilizer, or other fertile material must be applied before a good cover of plants can be established. In most places tile lines are needed on both sides of the waterways for grass to be established and maintained. The tile lines also help to keep erosion to a minimum and to reduce wetness so that the waterways can be crossed with farm machinery.

Other structures for controlling erosion.—Structures most commonly used in this county for the control of erosion consist of concrete structures, such as drop spillways, and of earth dams. Drop inlets controlling a head of 10 to *significant in engineering*—Continued

Classification—Continued	Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
AASHO	No. 4	No. 10	No. 200				
				Inches per hour	*Inches per inch of soil*	*pH value*	
A-2 to A-4	100	100	25-45	5.0-10.0	0.10	6.6-7.3	Low.
A-2	(1)	(1)	5-15	5.0-10.0	.03	5.6-6.5	Low.
A-6(10) to A-7-6(16)	100	100	95-100	0.5- 2.0	.20	5.1-5.5	Moderate to high.
A-7-6(14-18)	100	100	95-100	0.5- 2.0	.18	6.1-6.5	Moderate to high.
A-6(8) to A-7-6(16)	100	90-100	55-70	0.8- 2.5	.18	5.6-6.0	Moderate.
A-6(8) to A-7-6(16)	100	90-100	55-70	0.2- 0.8	.16	5.6-6.0	Moderate.
A-6(8) to A-7-6(16)	95-100	90-100	55-70	0.2- 0.8	.15	6.6-7.3	Moderate.
A-7-6(16-20)	100	100	95-100	<0.05	.18	5.6-6.0	High.
A-7-6(16-20)	100	100	95-100	<0.05	.17	5.6-6.0	High.
A-7-6(16-20)	100	100	95-100	0.2- 0.8	.18	6.6-7.3	High.
A-7-6(16-20)	100	100	95-100	<0.05	.17	6.6-7.3	High.
A-7-6(16-20)	100	100	95-100	<0.05	.17	6.6-7.3	High.
A-7-6(15-19)	100	100	95-100	0.2- 0.8	.20	5.6-6.5	High.
A-7-6(16-20)	100	100	95-100	<0.05	.17	5.6-6.0	High.

[3] Overwash material ranges from 6 to 16 inches in thickness and has properties similar to those of the uppermost layer in Nodaway silt loam.

25 feet are used to stabilize gully heads and lateral gullying and to provide outlets for grassed waterways. Concrete drop spillways are used to provide outlets for waterways and for tile in shallow, gullied areas.

Earth dams can readily be built in Cass County because suitable fill material commonly is available. Soil derived from glacial till or loess, depending on the location, is good fill material. Such material generally is classified as CL or ML. If the surface soil is highly organic, earth fills can be made relatively impervious by excavating a core trench in the highly organic material and backfilling with more impervious material. The more impervious material packs to a relatively high density and provides a stable structure for low heads. Drainage is needed to provide stability for slopes in high fills.

Each erosion control structure presents difficult problems. Technical assistance therefore should be obtained before major structures are planned.

Farm ponds.—By making water available to livestock on all parts of a farm, ponds help to control erosion because more of the acreage can be used for rotation grazing. Farm ponds also furnish water for livestock during extended dry periods when many wells in the county go dry. In addition they provide recreation for the family, and if located near buildings, they are a source of water for fire protection.

Ponds can be established in all parts of the county, but they generally are placed in the rolling hills in soils formed from glacial material. In most places watertight ponds can be constructed by excavating through the highly organic surface layer and backfilling with more impervious glacial material. In a few places strata or pockets of sand occur in the glacial till. This coarse-textured material presents special problems, and each site therefore needs to be thoroughly investigated.

Drainage and irrigation

Drainage is the chief engineering conservation practice, though some irrigation is done. These practices are discussed in the paragraphs that follow. Some features affecting the suitability of the soils for these uses are shown in table 4.

Drainage.—Many soils of Cass County require artificial drainage. Tile drainage is preferred if outlets are available and the soil is moderately permeable. Open ditches are used in areas where the soils are not suited to tile drainage or in places where outlets for tile are not readily available. Land grading is used in a few places, along with open ditches, for drainage of bottom lands.

The Bremer, Colo, and Nevin soils are examples of soils that can be drained effectively by tile. Tile works fairly well in the Zook soils, but supplemental surface drainage may be needed to make tillage less difficult. In the Bremer and Nevin soils, outlets for tile are difficult to obtain because of the distance from the wet area to a suitable outlet.

Soils of the Adair, Clarinda, and Judson series and of the Shelby-Adair complexes are among the soils of the county that are affected by seepage from higher lying soils. Installing interceptor tile lines at the upper boundaries of these soils helps to reduce the seepage.

Tile does not work well if placed in the Humeston and Wabash soils, because these soils have a very slowly permeable subsoil. In areas of these soils, a system of surface drains and open ditches is the best to use for removing surface water. In places, however, land grading can be used to improve surface drainage. Surface water can be removed from the Corley and Humeston soils, which generally occur in small depressions on benches, by use of shallow surface drains. Tile also can be used in these areas if a suitable outlet is available.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as a source of— Topsoil	Suitability as a source of— Road fill	Soil features affecting— Highway location	Soil features affecting— Farm ponds: Reservoir area
Adair (AdC2, AdD, AdD2, AdE2, ArC3, AsD3, AsE3). (For properties of Shelby soils in mapping units AsD3 and AsE3, refer to the Shelby series in this table.)	Poor	Not suitable to a depth of 3½ to 5 feet; good stability, compaction, and workability and low compressibility below a depth of 3½ to 4 feet; stones in some places.	Very plastic; seepage likely in cuts.	Very slow permeability; slow seepage.
Alluvial land (Au).[1]				
Ankeny (Ay)	Good	Good; fair to good stability; slight to medium compressibility, good compaction, bearing capacity, and workability; poor resistance to piping.	Erodes when exposed on embankments.	Not suitable soil; too porous to hold water.
Bremer (Br)	Fair in surface layer; very poor to not suitable below.	Very poor; fair to poor bearing capacity; fair stability; poor compaction; high shrink-swell potential; seasonal high water table.	Seasonal high water table; plastic.	Not suitable, because of topography.
Calco (Ca)	Good	Poor to very poor; fair to poor bearing capacity and shear strength; seasonal high water table; high compressibility.	Seasonal high water table; subject to flooding in places; poor foundation for high fills.	Not suitable, because of topography.
Clarinda (CdC, CdC2, CdD, CdD2, CeD3).	Not suitable	Not suitable; should not be used within 5 feet of grade in embankments.	Very plastic; wet and seepy in cuts.	Very slow permeability; slow seepage.
Colo (Cg, Ch, Cn) (For properties of Nodaway soil in mapping unit Cn, refer to the Nodaway series in this table.)	Good	Poor to very poor; fair to poor bearing capacity and shear strength; seasonal high water table; high compressibility.	Seasonal high water table; subject to flooding in places; poor foundation for high fills.	Not suitable, because of topography.
Corley (CoA)	Good	Poor; seasonal high water table; subject to ponding; fair to poor bearing capacity; fair to poor compaction.	Ponded in places in wet seasons; seasonal high water table.	Not suitable, because of topography.
Gara (GaD, GaD2, GaE, GaE2, GaF2, GrE3).	Fair to poor; surface layer is thin.	Good; good shear strength and bearing capacity; slight compressibility; good workability and compaction.	Good embankment material; in places cuts are seepy; stones occur in some places; rolling topography.	Slow seepage; moderately slow permeability; sand pockets and stones in a few places.
Hagener (HaD2)	Poor	Good; fair to good bearing capacity and shear strength; slight compressibility; highly erodible.	Highly erodible on exposed embankments; loose sand is likely to hinder hauling opertions; in places seepage occurs in deep cuts.	Material is too porous to hold water; compacted seal blankets or bentonite seal needed.

See footnote at end of table.

interpretations

Soil features affecting—Continued				
Farm ponds—Continued: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Fair stability to a depth of 4 feet and good below that depth; stones or boulders occur in a few places at a depth below 3½ to 4 feet; impervious for cores.	Wetness caused by seepage; use interceptor tile at contact zone between loess and till.	Slow intake of water; subject to runoff and erosion; seasonally wet and seepy.	Poor workability; difficult to vegetate channels and backslopes; interceptor tile is needed upslope; poorly suited to terraces.	Poor workability; difficult to vegetate; low fertility; generally wet.
Fair to good stability; good workability and compaction; erodible on slopes; poor resistance to piping.	Not needed	Low water-holding capacity; rapid intake of water, and frequent applications of water are needed.	Not needed, because of topography.	Not needed, because of topography.
Fair stability; poor compaction; high shrink-swell potential and compressibility.	Tile and surface drainage needed in places; protection from overflow needed in places.	Medium intake of water; high water-holding capacity; poorly drained; drainage needed.	Not needed, because of topography.	Not needed, because of topography.
High content of organic matter to a depth of 2 feet or more; fair to poor stability; poor workability and embankment foundation.	Tile and surface drains suitable if outlets can be obtained; occasional flooding; protection from overflow needed.	High water-holding capacity; medium intake of water; drainage and protection from overflow needed.	Not needed, because of topography.	Not needed, because of topography.
Fair stability on flat slopes; poor compaction; high shrink-swell potential; highly susceptible to cracking and slumping.	Use interceptor tile at contact zone between loess and till to intercept seepage; tile drains do not work well.	High water-holding capacity; subject to runoff and erosion; seasonally wet and seepy.	Not suitable; difficult to work and to vegetate channels and backslopes.	Difficult to work and to vegetate; wet and seepy.
High content of organic matter to a depth of 2 feet or more; fair to poor stability; poor workability and embankment foundation.	Tile and surface drains are suitable if outlets can be obtained; occasional flooding; protection from overflow needed.	High water-holding capacity; medium intake of water; drainage and protection from overflow needed.	Not needed, because of topography.	Not needed, because of topography.
Fair stability; fair to poor workability and compaction; slow permeability when compacted.	Subject to ponding after heavy rains; surface drains can be used if outlets can be obtained.	High water-holding capacity; medium intake of water; drainage needed to prevent ponding.	Not needed, because of topography.	Not needed, because of topography.
Good stability; slow permeability when compacted; good for impervious cores and blankets; good resistance to piping.	Not needed	High water-holding capacity; medium intake of water; subject to runoff and erosion; irrigation questionable because of topography.	Stony in places; channels and back slopes difficult to vegetate and erode readily; construction difficult on steep slopes; in places interceptor tile is required because of seepage from areas above.	Difficult to vegetate; erodes readily; adding fertilizer is helpful in establishing vegetation.
Fair strength and stability on flat slopes; poor resistance to piping; highly erodible.	Not needed	Low to very low water-holding capacity; intake of water is very rapid, and frequent applications of water are needed; subject to severe erosion.	Surface layer and subsoil are sandy and highly erodible; channels and backslopes are difficult to vegetate because of erosion and low fertility.	Sandy material; highly erodible and difficult to vegetate.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Humeston (Hu)	Fair in surface layer; very poor to not suitable below.	Very poor; poor workability; high shrink-swell potential; seasonal high water table; poor compaction; slow permeability when compacted; fair to poor bearing capacity.	Very plastic; seasonal high water table.	Not suitable, because of topography.
Judson (JdA, JdB, JdC, JoB). (For characteristics of Colo soil in mapping unit JoB, refer to the Colo series in this table.)	Good	Fair; fair to poor shear strength and bearing capacity; fair workability; medium to high compressibility; high content of organic matter to a depth of 2 feet or more.	Fair embankment material; high content of organic matter to a depth of 2 feet or more.	Moderate permeability if not compacted; pond bottom should be scarified and compacted to reduce seepage.
Kennebec (Ke)	Good	Poor; fair to poor bearing capacity; fair to good compaction; high compressibility; water table is high in years when rainfall is excessive.	Subject to flooding; high content of organic matter to a depth of 2 or 3 feet; poor foundation for high fills.	Not suitable, because of topography.
Ladoga (LaB, LaC, LaC2, LaD, LaD2, LaE, LaE2, LbB, LdD3, LdE3).	Good to fair except in severely eroded areas.	Poor; fair workability; fair to poor compaction; fair bearing capacity; moderate to high shrink-swell potential; medium to high compressibility.	In places deep cuts are wet and hard to excavate because of the underlying till; rolling topography.	Pond bottom should be compacted and scarified to reduce seepage; moderate permeability if not compacted.
Marsh (Ma)	Not suitable	Not suitable	Very wet or water stands on the areas during most of the year.	Not applicable
Marshall (MhA, MhB, MhC, MhC2, MhC3, MhD, MhD2, MhD3, MhE2, MhE3, MmA, MmB, MmC2).	Fair to good except in severely eroded areas.	Fair; fair to poor bearing capacity and shear strength; fair workability; medium to high compressibility.	Wet and hard to excavate below the water table in deep cuts; rolling topography.	Mapping units MhA through MhE3: moderate permeability when uncompacted; pond bottom should be scarified and compacted. Mapping units MmA, MmB, and MmC2: sites not suitable, because of topography.
Minden (Mn)	Good	Fair to poor; fair to poor bearing capacity and shear strength; medium to high compressibility; fair workability.	Nearly level soil; high content of organic matter to a depth of 1½ feet or more.	Not suitable, because of topography.
Nevin (Ne)	Good	Fair to poor; fair to poor bearing capacity; fair workability; high compressibility.	Nearly levelt opography; high content of organic matter to a depth of 1½ feet or more.	Not suitable, because of topography.
Nodaway (No, Nw)	Good	Fair; in places the water table is high in wet seasons; fair to poor bearing capacity; fair compaction; medium to high compressibility.	In places water table is high in wet seasons; subject to overflow.	Not suitable, because of topography.

interpretations—Continued

Soil features affecting—Continued				
Farm ponds—Continued: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Fair stability; poor compaction; high shrink-swell potential; good resistance to piping.	Tile drains do not work well; surface drains suitable if outlets can be obtained; protection from overflow needed.	High water-holding capacity; slow intake of water; poorly drained; drainage needed.	Not needed, because of topography.	Not needed, because of topography.
Fair stability, compaction, and workability; medium to high compressibility; high content of organic matter to a depth of 2 feet or more.	Drainage not needed; protection from runoff from adjacent slopes needed.	Medium intake of water; high water-holding capacity; subject to erosion on slopes and to runoff from adjacent uplands.	Diversions suitable if needed; no limitations for terraces if adjacent slopes are protected by conservation practices.	Soil properties favorable; no limitations.
Fair stability; fair compaction below a depth of more than 2 or 3 feet; poor embankment foundation.	Requires protection from overflow; tiling not needed.	Medium intake of water; high water-holding capacity; subject to overflow in places.	Not needed, because of topography.	Not needed, because of topography.
Fair stability; fair to poor compaction; slow permeability when compacted.	Not needed	High water-holding capacity; medium intake of water; rolling topography; subject to water erosion.	Soil conditions favorable; no other limitations except for mapping unit LbB, where topography may not be suitable.	Soil properties favorable; no limitations.
Not applicable	Some areas have potential for draining, but outlets generally are difficult to obtain.	Not applicable	Not applicable	Not applicable.
Fair stability, compaction, and workability; medium to high compressibility; fair resistance to piping.	Not needed	High water-holding capacity; medium intake of water; sloping or steep areas subject to erosion and runoff.	Soil properties favorable and no limitations, other than topography in mapping units MmA, MmB, and MmC2 may not be suitable.	Soil properties favorable; no limitations.
Fair stability; medium to high compressibility; fair to poor shear strength; fair resistance to piping.	Generally not needed, but water accumulates on some areas after rains, and these require surface drainage.	High water-holding capacity; medium intake of water.	Not needed, because of topography.	Not needed, because of topography.
Fair stability; high compressibility; fair to poor shear strength; fair resistance to piping.	Generally not needed; should be protected from overflow.	Medium intake of water; high water-holding capacity; drainage needed in places if irrigated.	Not needed, because of topography.	Not needed, because of topography.
Fair stability; moderate shrink-swell potential; poor resistance to piping; erodible on exposed embankments.	Should be protected from overflow; tile and surface drainage generally not needed.	High water-holding capacity; medium intake of water; subject to overflow.	Not needed, because of topography.	Not needed, because of topography.

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TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as a source of—		Soil features affecting—	
	Topsoil	Road fill	Highway location	Farm ponds: Reservoir area
Olmitz (OmB)	Good	Fair; fair bearing capacity; medium compressibility; fair to good workability and compaction; content of organic matter is fairly high to a depth of 2 feet.	Fair embankment material; content of organic matter is fairly high to a depth of 2 feet.	Moderate permeability above the underlying glacial till; moderately slow permeability and slow seepage in the glacial till.
Sandstone rock land (Sa)	Not suitable	Good to fair; erodes readily; low shrink-swell potential; good shear strength; slight compressibility; variable depth to sandstone bedrock.	In many places shallow to sandstone fragments or to bedrock; rolling topography; fair embankment material; high content of organic matter to a depth of 2 feet or more.	In many places shallow to bedrock or rock fragments; rapid permeability and seepage in surface layer; moderate permeability if not compacted; pond bottom should be scarified and compacted to reduce seepage.
Sharpsburg (SbA, SbB, SbC, SbC2, SbD, SbD2, SbD3, SbE2, SbE3).	Fair	Poor to very poor; fair to poor bearing capacity and shear strength; medium compressibility; high shrink-swell potential.	Plastic; in places wet and seepy in deep cuts.	Moderate to moderately slow permeability in the loess; moderately slow permeability and slow seepage in the underlying glacial till.
Shelby (ShC2, ShD, ShD2, ShE, ShE2, ShF2, SsD3, SsE3, SsF3, SyC2, SyD, SyD2, SyE2, SyF2, SyF3). (For properties of Adair soils in mapping units SyC2 through SyF3, refer to the Adair series in this table.)	Fair to poor; thin layer of material high in content of organic matter.	Good; good shear strength; slight compressibility; good workability and compaction.	Good embankment material; contains some stones and boulders; in places cuts are seepy; rolling topography.	Slow seepage; moderately slow permeability if not compacted; sand pockets and stones in a few places.
Wabash (Wa, Wb)	Poor	Very poor; high water table and shrink-swell potential; poor compaction and bearing capacity.	Plastic; high water table; subject to flooding.	Not suitable, because of topography.
Zook (Zo, Zk)	Poor	Very poor; high water table and shrink-swell potential; poor compaction and bearing capacity.	Plastic; high water table; subject to flooding.	Not suitable, because of topography.

[1] Variable.

interpretations—Continued

Soil features affecting—Continued				
Farm ponds—Continued: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Fair stability; fair to good workability and compaction; medium compressibility.	Not needed; protection from runoff from adjacent uplands needed.	High water-holding capacity; medium intake of water; protection from runoff from nearby slopes needed.	Diversions suitable if needed; no limitations for terraces if adjacent slopes are protected by conservation practices.	Soil properties generally favorable; no limitations.
In many places shallow to sandstone fragments or bedrock; generally not suited.	Not needed	Very rapid to rapid intake of water; very low water-holding capacity; tillage not feasible in most places.	Very shallow; subject to erosion.	In many places shallow to sandstone fragments or bedrock; construction difficult; very erodible and is difficult to vegetate.
Fair stability; fair to poor compaction; medium compressibility; high shrink-swell potential.	Not needed	High water-holding capacity; medium intake of water; sloping areas subject to runoff and erosion.	Soil properties favorable; no limitations.	Soil properties favorable; no limitations.
Good stability; slow permeability if compacted; good for impervious cores and blankets; good resistance to piping.	Not needed	High water-holding capacity; medium intake of water; subject to runoff and erosion.	Stones in some places; backslopes and channels are difficult to vegetate in places; difficult to build on steep slopes; channels and backslopes are subject to erosion.	Difficult to vegetate in many places; additional fertilizer needed to establish vegetation; erodes readily.
Fair to poor stability; high shrink-swell potential and compressibility.	Tile drains do not work well, excess water can be removed by open ditch and surface drains; outlets may be difficult to protect from overflow.	Very high water-holding capacity; drainage needed before irrigation; subject to overflow; intake of water variable because of cracking when dry.	Not needed, because of topography.	Not needed, because of topography.
Fair to poor stability; high shrink-swell potential and compressibility.	Tile drains work only fairly well, and open ditch and surface drains are sometimes needed in addition to tile to correct wetness.	Very high water-holding capacity; drainage needed before irrigation; subject to overflow; intake of water variable because of cracking when dry.	Not needed, because of topography.	Not needed, because of topography.

TABLE 5.—*Engineering test data for soil samples taken*

[Tests performed by the Iowa State Highway Commission in accordance with standard

Soil name and location	Parent material	Iowa report No. AAD1	Depth	Horizon	Moisture-Density [1]	
					Maximum dry density	Optimum moisture
			Inches		*Lb. per cu. ft.*	*Percent*
Colo silty clay loam: 354 ft. S. and 84 ft. E. of the N.W. corner of NW¼NW¼, sec. 33, T. 75 N., R. 36 W.	Alluvium.	12041	18–43	A31&A32	98	23
Kennebec silt loam: 480 ft. N. and 66 ft. W. of the SE. corner of SE¼SE¼, sec. 34, T. 75 N., R. 36 W.	Alluvium.	12040	18–40	A3&B11	96	22
Marshall silty clay loam: 120 ft. N. and 310 ft. W. of the SE corner of NE¼SE¼, sec. 23, T. 77 N., R. 37 W.	Wisconsin loess.	12036	0–13	A	95	23
		12037	20–33	B21	97	22
		12038	46–56	B32	101	19
Wabash silty clay: 250 ft. N. and 100 ft. E. of the SW corner of SE¼NW¼, sec. 13, T. 77 N., R. 36 W.	Alluvium.	12039	15–48	A3, B1, & B2g	95	23

[1] Based on AASHO Designation T 99–57, Method A, (*1*).
[2] Mechanical analyses according to AASHO Designation T 88–57 (*1*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the

Detailed information on drainage for the soils of Cass County can be obtained from the Iowa Drainage Guide, Special Report No. 13, published by Iowa State University.

Irrigation.—The use of irrigation for farming is limited in Cass County because the flow of streams during the irrigation season generally is small and the supply of underground water is inadequate. Reservoirs for maintaining a supply of water would be expensive to build and would be difficult to maintain because of the high rate of sedimentation. Further information about the suitability of the soils in the county for irrigation can be obtained from the Iowa Sprinkler Irrigation Guide, Special Report No. 11, published by Iowa State University.

Formation and Classification of Soils

In this section the factors that have affected the formation of the soils in Cass County are discussed. Also discussed is the classification of the soils by higher categories. Detailed descriptions of profiles considered representative of the series are given in the section "Descriptions of the 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 in the formation of soils. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has genetically related horizons. The effects of climate and 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. Generally a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The principal parent materials in Cass County are loess, glacial till, alluvium, and windblown sand. Less extensive parent material is residuum, weathered in place from bedrock. The relationship of the major soils in Cass County to parent material and to position on the landscape is shown in figure 11.

Loess, which was deposited by wind, is the most extensive parent material in the county. It consists mainly of silt but includes small amounts of clay and is assumed to have been calcareous when deposited. Unweathered loess is silt loam to light silty clay loam in texture. The mineral *from selected soil profiles, Cass County, Iowa*

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—		Percentage smaller than—						AASHO [3]	Unified [4]
No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.	0.001 mm.				
100	99	97	50	43	39	57	36	A-7-6(19)	CH.
100	96	91	33	26	21	42	21	A-7-6(13)	CL.
------------	100	91	36	27	22	43	20	A-7-6(13)	CL.
------------	100	91	39	33	29	45	22	A-7-6(14)	CL.
------------	100	90	33	27	24	42	22	A-7-6(13)	CL.
100	98	93	59	48	37	68	42	A-7-6(20)	CH.

material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[3] Based on AASHO Designation M 145-49 (*1*).

[4] Based on the Unified Soil Classification System (*30*).

composition is heterogeneous (*8*), and mineral plant nutrients are abundant.

The Corley, Ladoga, Marshall, Minden, and Sharpsburg soils formed in loess. In general, the mantle of loess is thickest on the nearly level flats and wide divides in the uplands. Much of the loess on the side slopes has been washed away. The amount remaining depends on the steepness of the slope and its position. The physical characteristics of the Minden soils as they occur in adjoining Shelby County are described in a study made by Ulrich (*26*), and those of the Corley, Minden, and Marshall soils on benches are described in a study made by Corliss and Ruhe (*3*).

Glacial till is the second most extensive parent material in Cass County. Most of this glacial till is from the Kansan glaciation. The unweathered glacial 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 (*8*) and is similar to that of the particles in unweathered loess.

Soils formed on the Kansan till plain during the Yarmouth and Sangamon interglacial ages. This was before the loess was deposited. On the nearly level areas the soils were strongly weathered and had a gray clay subsoil called gumbotil (*7, 32*). This gumbotil is several feet thick and is very slowly permeable. The only primary minerals remaining in these strongly weathered soils are those most resistant to weathering. Soils that formed on the more sloping parts of the Kansan till plain were less strongly weathered, more reddish, and not so thick as soils that formed on level areas. These more sloping soils formed during the Sangamon interglacial stage. They have a layer of pebbles or a stone line in the upper part in most places (*16*).

The soils that formed during the Yarmouth and Sangamon ages were covered by loess during the Wisconsin age (*32*). They are called *paleosols* (fig. 12). Several studies of buried soils have been made (*14, 17, 20, 21, 22*). In one of his studies, Simonson concluded that the buried soils had been altered by bases that leached from the overlying materials and resaturated the buried soils (*21*).

Geologic erosion has removed the loess from many slopes and has exposed strongly weathered paleosols. In some places the paleosols have been beveled or truncated so that only the lower part of the strongly weathered soil remains. In other places erosion has removed all of the paleosol and has exposed till that is only slightly weathered at the surface.

The parent material of soils derived recently from till ranges from relatively unweathered till to strongly weathered paleosols. The unweathered till occupies areas where geologic erosion has been most active. The Clarinda soils have formed where the most strongly weathered, gray paleosols crop out. The Adair soils have formed where the less strongly weathered, reddish paleosols crop out. Shelby and Gara soils have formed in unweathered or only slightly weathered Kansan till that has had the overlying paleosols removed by geologic erosion.

Alluvium is the third most extensive parent material in Cass County. It consists of sediment laid down along major streams and narrow upland drainageways and on low benches. The texture of the alluvium varies widely because of differences in the materials from which it came and in the time it was deposited.

284-563 O—68——6

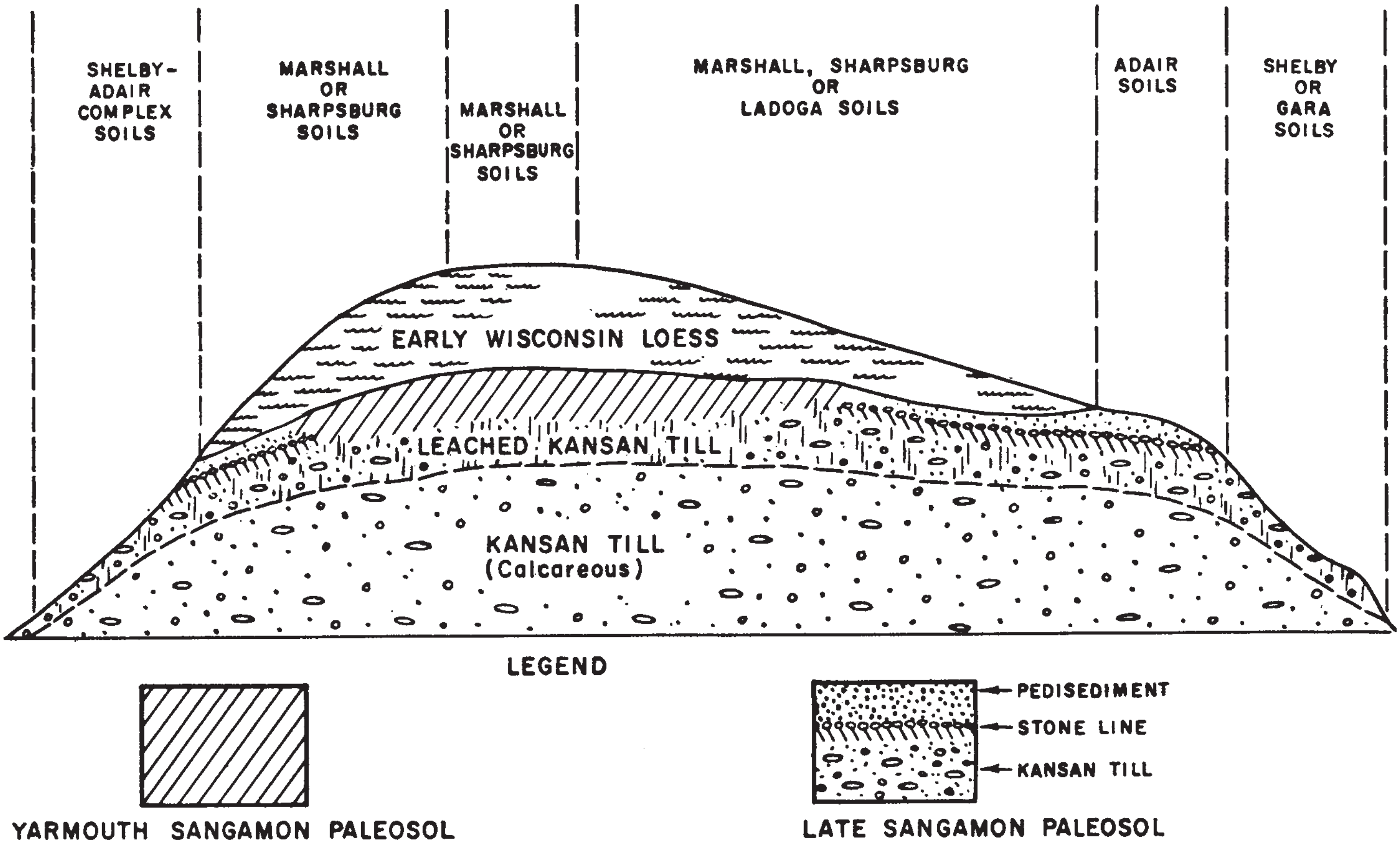

***Figure 11.*—Relationship of the major soils in Cass County to parent material and to position on the landscape.**

Some of the alluvial material has been transported only short distances and is called local alluvium. Such alluvium retains many of the characteristics of the soils from which it has washed. The Judson soils, for example, generally are at the base of slopes below soils formed in loess. The material in which they formed washed or rolled down the slope. Judson soils generally are silt loam in texture, as are the loess-derived soils.

The Nodaway and Ankeny soils and Alluvial land have formed in recent alluvium and range from silt loam to sandy loam or sand in texture. The Kennebec, Colo, Zook, and Wabash soils, listed in order of increasingly finer texture, have formed in alluvium consisting of local sediment washed from nearby uplands and intermixed with sediment that washed from longer distances. These soils are older and darker colored than the Ankeny and Nodaway soils and Alluvial land. The Bremer and Nevin soils and Wabash silty clay loam formed in still older alluvium. These soils are above the level of the present flood plain on low benches. They are either silty or clayey, depending on the source of the alluvium or on the way the material was sorted or deposited by the floodwater.

Windblown sand is not an extensive parent material in Cass County. It occurs on north- and west-facing slopes along the East Nishnabotna River, Troublesome Creek, and Turkey Creek and along minor tributaries of these streams. This sandy material is believed to have originated in valleys of these streams in the Late Wisconsin period. Later it was blown by wind onto slopes along the streams.

Windblown sand consists chiefly of quartz, which is very resistant to weathering. It has not been altered much since it was deposited. Hagener soils are the only soils in Cass County formed in windblown sand. They have a high content of sand and a low content of clay.

Residuum is the material derived from the weathering of rock in place. It is a minor parent material in Cass County and is derived mainly from limestone, shale, and sandstone. In most of the county, the bedrock is buried beneath loess, glacial till, alluvium, and windblown sand.

Most of the limestone and shale are of the Carboniferous period and belong to the Missouri series of Pennsylvanian age (*25*). These rocks are exposed in the western part of the county along valleys of the East Nishnabotna River and of Indian Creek and Spring Creek. Most of the outcrops of these rocks are in the southwestern part of the county. They are small, and many areas are shown on the detailed soil map by symbols for rock outcrops.

The remaining bedrock in the county is Dakota sandstone of Upper Cretaceous time. In many places this sandstone overlies the Pennsylvanian limestone and crops out below areas of loessal and glacial deposits. Sandstone rock land is the only mapping unit derived from sandstone in this county.

Climate

Cass County soils, according to recent evidence, have been developing under the influence of a variable climate.

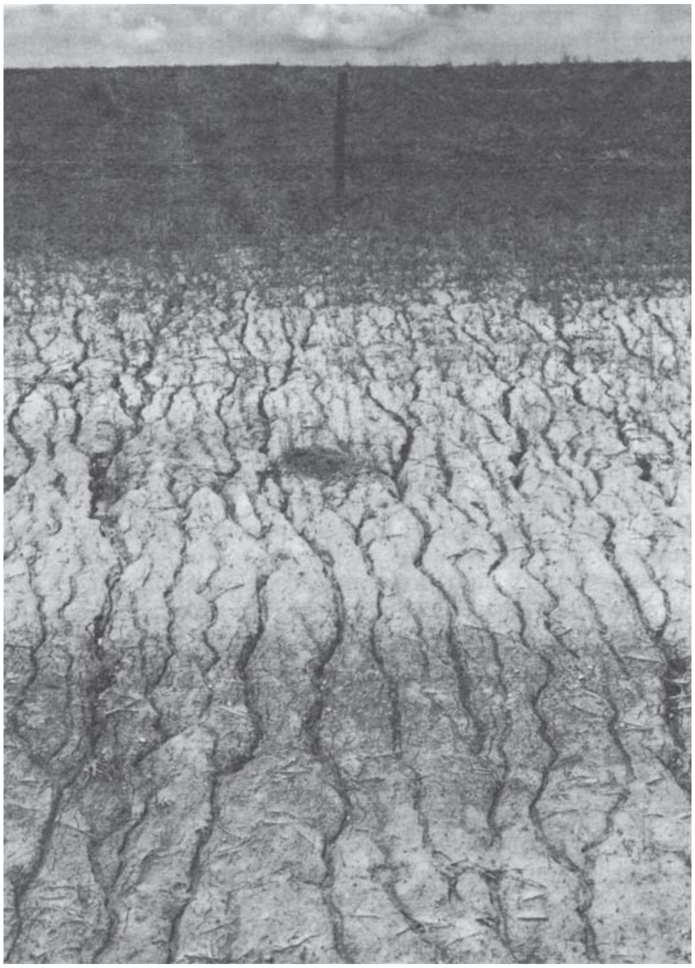

Figure 12.—**Roadcut showing a paleosol covered by loess.**

Walker (*29*) in recent studies concluded that in the post-Cary glaciation, which occurred between 10,500 and 13,000 years ago, the climate was cool and the vegetation was dominantly conifers. Between about 8,000 to 10,500 years ago, however, the climate became warmer. As a result, the vegetation changed from forests of conifers to a mixed forest in which hardwoods were prominent. Then about 8,000 years ago the climate became warmer and drier. Herbaceous prairie plants became dominant and have remained so to the present time. McComb and Loomis (*11*) concluded from studies made of the transition from forest to prairie in central Iowa that a late change in postglacial climate from a fairly dry climate to a climate marked by a moderate amount of moisture has taken place. Walker's evidence indicates that this change to a midcontinental subhumid climate probably occurred about 3,000 years ago.

Nearly uniform climate prevails throughout Cass County. Therefore, although the climate generally has had an important influence on the characteristics of the soils, it has not caused major differences among them. Weathering of the parent material by water and by air is activated by changes in temperature. As the result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its affect on the amount of leaching in soils and on the kind of plants that grow.

The influence of the general climate of a region is modified by local conditions in or near a developing soil. For example, soils on south-facing slopes, such as the Hagener soils, formed under a microclimate that is warmer and drier than the average climate of nearby areas. On the other hand, poorly drained Corley soils, and other soils that formed in low areas, where water is likely to pond, have formed under a colder and wetter climate than surrounding soils. These local differences influence the characteristics of the soils and account for some of the differences among soils within the same general climatic region.

Plants and animals

Vegetation has greatly influenced the development of soils in Cass County and has caused some differences in morphology among the soils. The native vegetation in the county was mainly big and little bluestem grasses, but a few areas on slopes that border the major streams and their tributaries were in trees (*31*).

According to original land surveys, made between 108 and 135 years ago, about 30,720 acres in Cass County were under forest. In 1954, however, only about 9,000 acres were wooded (*5*). In Cass County the Gara and Ladoga soils are the only soils formed mainly under forest vegetation. These soils make up about 10,000 acres, which is about the same as the acreage estimated as wooded in 1954. The difference in area of soils formed under forest and the area originally estimated as under forest is probably because many of the areas in the original land survey had brush or young trees on them or only scattered trees. In such areas the woody vegetation did not markedly affect the soils.

Marshall soils are an example of soils that formed under prairie grasses. The prairie grasses have thick, fibrous roots that penetrate the soil to a depth of 12 to 15 inches. Because of this vegetation, Marshall soils have a thicker, darker colored surface layer than do soils that formed under trees, and this layer contains more organic matter and nitrogen. Also, soils that formed under trees generally are more acid than soils that formed under grass. Soils, such as the Ladoga, however, have properties intermediate between soils formed entirely under prairie grasses and soils formed entirely under trees. It is believed that Ladoga soils first developed under prairie grasses and then later trees encroached on the areas.

Micro-organisms also have an important part in the development of the soil profile. They are a source of organic matter. They also help to break down organic matter, to change soil structure, and to make nutrients stored in the organic matter available to plants.

Insects, worms, rodents, and man also have influenced formation of soils. Man, in particular, has been responsible for extensive changes in the soils by removing the cover of plants on sloping areas and thus causing accelerated erosion.

Relief

Relief, or topography, refers to the lay of the land. It ranges from nearly level to very steep in Cass County. Relief is an important factor in soil formation because of its effect on drainage, runoff, the height of the water table, and erosion.

Even though soils have formed from the same parent material, the influence of relief is seen in the color, thickness, and horizonation of the soils. In level areas, both in the uplands and on benches, soils have a thicker surface layer and a more mottled subsoil than soils in more sloping areas. Also the clay content of the B horizon generally is greater. This is because water runs off more slowly, more of it percolates through the soil, and thus more clay is moved downward from the A horizon into the B horizon. In addition soils on summits are older than those on side slopes, and in this way, relief affects the soil forming factor of time.

The soil forming factor of climate also is affected by relief. Nearly level areas or areas in depressions collect and hold water for a period of time, and soils in such areas are more poorly drained and colder than those on slopes where runoff is more rapid. Examples of soils formed in drier and warmer areas are the Sharpsburg soils, in sloping areas. Bremer soils are examples of soils formed on nearly level benches or in depressions.

Relief also affects the color of the B horizon through its affect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. On the other hand, the subsoil of soils that have restricted drainage is gray or mottled. Marshall soils are examples of soils that have good drainage, and Corley soils are examples of soils that have poor drainage.

Time

Time is required for climate and living organisms to affect the parent material of soils. The soils of Cass County range from extremely young to very old. The Nodaway soils are young. They have formed in alluvial material, some of which was deposited after the county was settled. The Clarinda soils are very old and formed from till that weathered for perhaps 450,000 years during the Yarmouth and Sangamon interglacial ages (*7*). This material was covered by loess during the Early Wisconsin age (*17*). More recently the material has been exposed to weathering again when the loess was removed by erosion. As a result of the long periods of weathering, the Clarinda soils have a fine-textured B horizon, 3 to 8 feet thick.

Adair soils have a history of formation similar to that of the Clarinda soils, but the Adair soils probably weathered for only 115,000 years before they were covered by the loess. Further weathering has taken place since the loess was removed. The Adair soils are also old but are younger than the Clarinda soils. The B horizon of Adair soils is 2 to 4 feet thick and is moderately fine to fine in texture.

Like the Adair and Clarinda soils, the Shelby soils have formed in glacial till. Shelby soils, however, have weathered only during Late Wisconsin and Recent times, or for a period of 14,500 years or less. The B horizon of the Shelby soils is 1½ to 3 feet thick and is moderately fine in texture.

The radiocarbon technique (*19*) for determining the age of carbonaceous material found in loess and till has been useful in dating soils formed partly in Wisconsin age. According to Ruhe and Scholtes (*17*), Early Wisconsin is the age of the upper part of the Wisconsin loess on uneroded uplands. Based on these dates the age of loessal soils on stable divides, such as the nearly level Minden, Marshall, and Sharpsburg soils, is about 14,000 years. Much of the loess has been removed from the side slopes by geologic erosion and deposited downslope (*18*), where it has accumulated to form local alluvium. The soils that have formed on the side slopes that ascend to the divides are not older than those on the divides and some are less than 1,800 years old (*4*). The base of the alluvium in stream valleys is less than 1,800 years old. From this material the Colo, Kennebec, Nodaway, Wabash, Zook, and similar soils formed.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to 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.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and later revised (*24*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*23*, *28*). Therefore, readers interested in developments of this system should search the latest literature available. In this subsection some of the classes in the current system and the great soil groups of the older systems are given for each soil series in table 6. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates.

Table 6 shows the three soil orders in Cass County—Entisols, Mollisols, and Alfisols. Entisols are recent mineral soils that do not have genetic horizons or have only the beginnings of such horizons. Mollisols have surface layers that are darkened by organic matter. Alfisols have argillic horizons with more than 35 percent base saturation.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in

TABLE 6.—*Soils series classified according to the current system of classification and the 1938 system with its later revisions*

Series	Current system [1]			1938 classification
	Family	Subgroup	Order	Great soil group
Adair	Fine, montmorillonitic, mesic [2]	Aquic Argiudolls	Mollisols	Brunizems.
Ankeny	Coarse-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems.
Bremer	Fine, montmorillonitic, noncalcareous, mesic.	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Calco	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils intergrading to Alluvial soils.
Clarinda	Fine, montmorillonitic, noncalcareous, mesic, sloping.[2]	Vertic Argiaquolls	Mollisols	Humic Gley soils.
Colo	Fine-silty, mixed, noncalcareous, mesic.	Cumulic Haplaquolls	Mollisols	Humic Gley soils intergrading to Alluvial soils.
Corley	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols	Planosols.
Gara	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols	Gray-Brown Podzolic soils intergrading to Alluvial soils.
Hagener	Sandy, mixed, mesic	Entic Hapludolls	Mollisols	Brunizems.
Humeston	Fine, montmorillonitic, mesic	Argiaquic Argialbolls	Mollisols	Planosols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols	Gray-Brown Podzolic soils intergrading to Brunizems.
Marshall	Fine-silty, mixed, mesic [2]	Typic Hapludolls	Mollisols	Bruinzems.
Minden	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols	Brunizems.
Nevin	Fine-silty, mixed, mesic	Aquic Argiudolls	Mollisols	Brunizems.
Nodaway	Fine-silty, mixed, mesic	Typic Udifluvents	Entisols	Alluvial soils.
Olmitz	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Brunizems.
Sharpsburg	Fine, montmorillonitic, mesic [2]	Typic Argiudolls	Mollisols	Brunizems.
Shelby	Fine-loamy, mixed, mesic [2]	Typic Argiudolls	Mollisols	Brunizems.
Wabash	Fine, montmorillonitic, noncalcareous, mesic.	Vertic Haplaquolls	Mollisols	Humic Gley soils.
Zook	Fine, montmorillonitic, noncalcareous, mesic.	Cumulic Haplaquolls	Mollisols	Humic Gley soils.

[1] Placement of some soil series in the current system of classification, particularly in families, may change as more information becomes available.

[2] The severely eroded Mollisols are outside the allowable range of any series defined as a Mollisol. It is expected that in the future the severely eroded units will be classified in new series. Pending further study and recommendations by the National Cooperative Soil Survey they are being correlated as severely eroded phases in this correlation.

the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging, or soil differences resulting from climate or vegetation.

GREAT GROUP: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans that interfere with growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 6, because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group and the others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is *Typic Hapludolls*.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. An example is the *fine-silty, mixed, mesic family of Typic Hapludolls*.

SERIES: The series consists of a group of soils that formed from a particular kind of parent material and have genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

New soil series must be established and concepts of some established series, especially older ones that have been used little in recent years, must be revised in the course of the soil survey program across the country. A proposed new series has tentative status until review of the series concept at state, regional, and national levels of responsibility for soil classification results in a judgment that the new series should be established. All of the soil series described in this survey have been established.

Laboratory Analyses

In table 7 data obtained by mechanical and chemical analyses for three selected soils of the Marshall series in Cass County are given. A profile description of sample number S–63–Ia–15–2 is given in the section "Descriptions of the Soils."

The data in table 7 are useful to soil scientists in classifying soils and in learning how the soils formed. They are also helpful in estimating water-holding capacity, wind erosion, fertility, tilth, and other properties that affect soil management.

Samples of the Marshall soils for which the data are given were taken in the same field in the NW¼SE¼ of sec. 34, T. 77 N., R. 37 W., in the northwestern part of the county. Sample S–63–Ia–15–1 was taken on a moderately broad, slightly convex, upland divide that had a slope of less than 1 percent. Sample S–63–Ia–15–2 was taken on a stable convex slope of about 3 percent that faced west, and sample S–63–Ia–15–3 was taken on a nearly unstable convex side slope of 7 percent downslope from the other two samples.

A number of systematic trends are shown by the data in table 7. Depth to the layer of maximum clay accumulation, thickness of the solum, and depth to the silt loam texture all decrease as the gradient of the slope increases. The thickness of material that is 0.58 percent or more organic carbon also decreases, as well as the depth to relict mottles that have a chroma of 2. Data from adjacent Shelby County, based on Marshall soils sampled in a similar transverse position, indicate that the depth to pH values of 6.1 or more also systematically decreases with increasing slope. The data in table 7 for samples S–63–Iowa–15–1 and S–63–Iowa–15–2 indicate a similar reac-

TABLE 7.—*Analytical data*

[Analyses were made at Soil Survey Laboratory, Soil Conservation Service, Lincoln, Nebr.

Soil name, location, and sample number	Horizon	Depth	Particle size distribution: Total: Sand (2.0 to 1.0 mm.)	Total: Silt (0.05 to 0.002 mm.)	Total: Clay (less than 0.002)	Sand: Very coarse (2.0 to 1.0 mm.)	Sand: Coarse (1.0 to 0.5 mm.)	Sand: Medium (0.5 to 0.25 mm.)	Sand: Fine (0.25 to 0.10 mm.)	Sand: Very fine (0.10 to 0.05 mm.)	Silt (0.05 to 0.002 mm.)
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Marshall silty clay loam:	Ap	0–7	2. 3	69. 1	28. 6	(2)	0. 1	0. 1	0. 2	1. 9	37. 9
642 feet south of the center of the	A12	7–16	2. 0	65. 0	33. 0	(2)	. 1	. 1	. 2	1. 6	33. 9
road and 719 feet east of the	A3	16–23	2. 2	64. 4	33. 4	(2)	. 1	. 1	. 2	1. 8	33. 2
northwest corner of NW¼SE¼	B21	23–28	2. 7	63. 3	34. 0	0. 1	. 2	. 2	. 3	1. 9	33. 0
sec. 34, T. 77 N., R. 37 W., Cass	B22	28–36	3. 2	64. 3	32. 5	------	. 2	. 2	. 4	2. 4	36. 4
County, Iowa (S–63 Iowa–15–1).	B23	36–44	3. 6	66. 3	30. 1	------	. 1	. 2	. 3	3. 0	38. 2
	B31	44–52	3. 7	67. 8	28. 5	------	. 1	. 1	. 2	3. 3	39. 5
	B32	52–60	3. 4	47. 4	29. 2	------	. 1	. 1	. 2	3. 0	39. 1
	C1	60–72	3. 6	68. 9	27. 5	------	(2)	. 1	. 2	3. 3	40. 0
Marshall silty clay loam: 820 feet	Ap	0–7	2. 8	66. 3	30. 9	. 1	. 1	. 1	. 2	2. 3	38. 4
south of the center of the road	A12	7–13	2. 5	64. 5	33. 0	------	. 1	. 1	. 2	2. 1	36. 1
and 500 feet east of the north-	A3	13–18	2. 7	64. 1	33. 2	(2)	. 2	. 1	. 2	2. 2	35. 5
west corner of NW¼SE¼ sec. 34,	B21	18–26	3. 7	64. 5	31. 8	(2)	. 2	. 2	. 4	2. 9	36. 7
T. 77 N., R. 37 W., Cass County,	B22	26–34	3. 7	68. 5	27. 8	------	. 1	. 1	. 3	3. 2	38. 1
Iowa (S–63–Iowa–15–2).	B31	34–41	4. 1	67. 7	28. 2	------	. 1	. 1	. 3	3. 6	39. 4
	B32	41–47	3. 6	67. 3	29. 1	------	. 1	. 1	. 4	3. 0	38. 2
	B33	47–58	4. 0	68. 3	27. 7	------	. 1	. 1	. 3	3. 5	40. 6
	C1	58–68	3. 9	69. 2	26. 9	------	(2)	. 1	. 3	3. 5	39. 3
	C2	68–72	3. 2	68. 8	28. 0	------	. 1	. 1	. 2	2. 8	40. 4
	C3	72–76	3. 4	68. 3	28. 3	------	(2)	(2)	. 2	3. 2	39. 6
Marshall silty clay loam: 798 feet	Ap	0–6	3. 3	65. 0	31. 7	------	. 1	. 1	. 2	2. 9	39. 5
south of the center of the road	A3	6–10	3. 0	63. 7	33. 3	------	(2)	. 1	. 2	2. 7	36. 3
and 379 feet east of the north-	B21	10–18	2. 9	65. 8	31. 3	------	(2)	. 1	. 2	2. 6	36. 6
west corner of the NW¼SE¼ sec.	B22	18–25	2. 8	67. 2	30. 0	------	(2)	. 1	. 2	2. 5	36. 9
34, T. 77 N., R. 37 W., Cass	B31	25–32	3. 0	67. 4	29. 6	------	(2)	. 1	. 2	2. 7	37. 8
County, Iowa (S–63–Iowa–15–3).	B32	32–39	2. 6	68. 2	29. 2	------	(2)	. 1	. 2	2. 3	38. 2
	B33	39–44	2. 5	69. 7	27. 8	------	(2)	. 1	. 2	2. 2	40. 1
	B34	44–47	------	------	------	------	------	------	------	------	------
	C1	47–53	2. 7	69. 0	28. 3	------	(2)	(2)	. 1	2. 6	40. 9
	C2	53–58	2. 4	71. 0	26. 6	------	(2)	(2)	. 2	2. 2	39. 9
	C3	58–60	2. 3	69. 9	27. 8	------	(2)	(2)	. 1	2. 2	39. 1
	C4	60–63	2. 3	72. 1	25. 6	------	(2)	(2)	. 2	2. 1	40. 1
	C5	63–69	3. 4	72. 4	24. 2	------	(2)	. 1	. 5	2. 8	42. 0
	C6	69–77	2. 7	71. 4	25. 9	------	(2)	. 1	. 2	2. 4	39. 4

[1] A bar is about 0.987 atmosphere of pressure. [2] Trace.

tion, but that for the remaining sample shows that it is medium acid to a depth of 44 inches. Although these properties have a systematic relationship to the increasing gradient of a slope, they may be partly because of differences in the age of materials. In general soils on side slopes are younger than those on summits (*6*, *18*).

All samples used to obtain the data in table 7 were collected from carefully selected pits. The samples are considered representative of the soil material that is made up of particles less than three-fourths of an inch in diameter. Unless otherwise noted, all laboratory analyses recorded in table 7 were made on material that passed the 2 millimeter sieve, and the data are reported on an ovendry basis.

If necessary, the samples were sieved after being dried, and rock fragments larger than three-fourths of an inch were discarded. The material less than three-fourths of an inch was rolled, crushed, and then sieved by hand to remove rock fragments larger than 2 millimeters in diameter.

Standard methods of the Soil Survey Laboratory were used to obtain most of the data in table 7. The particle size analysis was made by the pipette method (*9*, *10*, *12*). Organic carbon was determined by wet combustion, using a modification of the Walkley-Black method (*13*). Reaction was determined with a glass electrode at 1 : 1 soil-water ratio.

General Nature of the County

This section was written chiefly for those not familiar with Cass County. It discusses physiography, relief, and drainage; water supply; climate; settlement and population; community and farm facilities and industries; and

for selected soil profiles

Dashes in columns indicate values were not determined]

Particle size distribution—Continued: 0.02 to 0.002 mm.	Particle size distribution—Continued: 0.20 to 0.02 mm.	Particle size distribution—Continued: 2.0 to 0.1 mm.	Organic carbon	Nitrogen	Carbon-nitrogen ratio	Bulk density: Field state	Bulk density: ⅓ bar [1]	Bulk density: Air-dry	Coefficient of linear expansibility	Water content at—: Field state	Water content at—: ⅓ bar [1]	Water content at—: 15 bar [1]	Water content at—: ⅓ to 15 bar [1]	Reaction (water 1:1)	Extractable acidity	Ratio to clay: 15 bar water [1]
Percent	*Percent*	*Percent*	*Percent*	*Percent*		*Gm./cc.*	*Gm./cc.*	*Gm./cc.*		*Percent*	*Percent*	*Percent*	*In./In.*	*pH*	*Meq./100 gm.*	
31.2	39.9	0.4	2.46	0.189	13	1.34	1.34	1.44	0.024	25.3	25.2	12.5	0.17	5.6	12.7	0.44
31.1	35.6	.4	2.14	.172	12	1.19	1.16	1.28	.032	29.0	32.7	14.0	.22	5.7	11.9	.42
31.2	35.1	.4	1.61	.142	11	1.22	1.19	1.34	.040	28.5	32.4	14.6	.21	5.9	10.3	.44
30.3	35.1	.8	1.00	.093	11	1.26	1.24	1.42	.047	28.2	28.5	15.7	.16	5.9	8.6	.46
27.9	39.0	.8	.58	.062	9	1.28	1.28	1.45	.044	26.9	28.1	15.2	.16	6.0	7.5	.47
28.1	41.3	.6	.33	--------	-------	1.38	1.33	1.48	.036	20.6	27.1	14.6	.17	6.1	6.2	.49
28.3	42.9	.4	.22	--------	-------	1.38	1.32	1.46	.036	22.5	26.3	14.0	.16	6.2	5.5	.49
28.3	42.2	.4	.15	--------	-------	1.36	1.32	1.46	.036	25.1	27.4	14.1	.18	6.4	4.8	.48
28.9	43.4	.3	.13	--------	-------	1.34	1.30	1.42	.028	26.7	28.3	13.7	.19	6.5	4.0	.50
27.9	40.8	.5	2.14	.179	12	1.42	1.42	1.53	.024	24.4	24.0	13.5	.15	5.6	12.6	.44
28.4	38.3	.4	1.82	.151	12	1.23	1.22	1.33	.028	28.1	27.1	13.7	.16	5.9	9.8	.42
28.6	37.8	.5	1.37	.125	11	1.24	1.22	1.36	.036	27.4	26.8	14.2	.15	6.0	9.8	.43
27.8	39.8	.8	.62	.065	10	1.20	1.21	1.34	.036	28.0	25.4	14.3	.13	6.1	7.2	.45
30.4	41.4	.5	.46	.047	10	1.22	1.24	1.36	.032	27.3	25.4	14.0	.14	6.1	5.8	.50
28.3	43.1	.5	.33	------	-------	1.29	1.28	1.42	.036	26.6	25.2	13.5	.15	6.2	4.9	.48
29.1	41.4	.6	.22	------	-------	-----	----	----	-------	-----	----	13.9	----	6.2	5.1	.48
27.7	44.3	.5	.16	------	-------	1.34	1.30	1.43	.032	23.9	26.8	12.0	.19	6.2	5.0	.43
29.9	43.0	.4	.13	------	-------	1.36	1.32	1.44	.028	25.2	26.2	13.0	.17	6.3	4.3	.48
28.4	43.3	.4	.13	------	-------	1.38	1.32	1.44	.028	26.2	26.7	14.2	.16	6.4	3.9	.51
28.7	42.9	.2	.08	------	-------	-----	----	----	-------	-----	----	13.4	----	6.5	3.2	.47
25.5	42.5	.4	2.05	.170	12	1.39	1.40	1.52	.028	26.6	25.0	13.7	.16	5.6	11.0	.43
27.4	39.1	.3	1.45	.129	11	1.23	1.23	1.34	.028	28.3	27.3	13.0	.18	5.6	10.1	.39
29.2	39.3	.4	.86	.085	10	1.22	1.20	1.32	.032	28.2	27.2	13.2	.17	6.0	7.6	.42
30.3	39.5	.3	.54	.058	9	1.20	1.20	1.32	.032	28.4	26.1	13.6	.15	5.9	6.5	.45
29.6	40.6	.3	.33	------	-------	1.22	1.25	1.39	.036	28.8	27.2	14.6	.16	5.9	5.8	.49
30.0	40.6	.3	.24	------	-------	1.30	1.27	1.41	.036	28.3	27.6	14.3	.17	5.9	5.6	.49
29.6	42.4	.3	.17	------	-------	1.34	1.31	1.44	.032	22.0	27.6	14.0	.18	6.0	5.6	.50
------	----	----	.19	------	-------	1.23	1.22	1.34	.032	29.0	33.2	12.8	.25	6.1	6.2	.49
28.1	43.6	.1	.10	------	-------	1.36	1.32	1.46	.036	24.4	28.1	13.8	.19	6.4	3.5	.49
31.1	42.2	.2	.13	------	-------	1.36	1.32	1.43	.028	25.3	27.9	13.1	.20	6.4	3.5	.49
30.8	41.4	.1	.08	------	-------	-----	----	----	-------	-----	----	13.3	----	6.4	4.0	.48
32.0	42.3	.2	.07	------	-------	-----	----	----	-------	-----	----	14.0	----	6.5	3.2	.55
30.4	45.2	.6	.06	------	-------	1.36	1.30	1.40	.024	28.6	29.1	13.2	.21	6.5	3.7	.55
32.0	41.9	.3	.06	------	-------	1.39	1.32	1.45	.032	28.9	28.8	13.4	.20	7.0	1.9	.52

transportation and markets. It also gives facts about the agriculture.

Physiography, Relief, and Drainage

Cass County is part of an extensive glacial drift plain, mantled with loess, that slopes gently toward the southwest and is cut by streams that flow south and southwest (*25*). All of the valleys of the larger streams have a well-developed flood plain that is bordered by an older flood plain, or second bottom.

The chief streams dissecting the county are the East Nishnabotna River and Turkey, Troublesome, and Indian Creeks. Along the lower reaches of the valleys of each of these streams is a broad flood plain bordered by second bottoms or low benches. The second bottom of the East Nishnabotna River and of Indian Creek is about 8 feet above the present flood plain. This second bottom extends southwestward from Lewis to the county line and ranges from 1 to 3 miles in width. The second bottom of the East Nishnabotna River also extends from Lewis northward along the river to several miles north of Atlantic. Along Indian Creek north of Lewis, the second bottom of Indian Creek is also evident in many places northward to the county line.

The relief of the county ranges from nearly level to steep. Along the eastern side of the county in Lincoln Township, the terrain is rolling. The valleys become progressively deeper and broader to the south and southwest. They are deepest along the south county line, and the terrain here is the most rugged in the county. The lowest elevation is 1,080 feet and is in the bed of Spring Creek, west of Lewis; and the highest is 1,317 feet, on the first hill south of Cumberland (*25*).

The landscape of Cass County is characteristic of that occurring in much of southern Iowa. A landscape similar to that in Cass County has been studied in detail by Ruhe (*15*). Ruhe observed that the slopes along the axis of the interfluves are broken in many areas at two or three places by distinct changes in gradient. Each interfluve has a sequence of stepped levels that rise from the valley shoulders to the upland divide. Ruhe concluded that this sequence of levels is the result of multicyclic erosion of glacial till landscape that has been further complicated by a mantle of loess.

The relief is closely related to the geologic deposits, especially those of the Kansan and post-Kansan stages (*25*). The present landscape was formed in the Pleistocene period during the Late Wisconsin interglacial stage. In this period deposits first laid down by the Nebraskan glacial stage and later by the Kansan glacial stage were covered by loess. Underlying the loess and glacial material is Dakota sandstone of the Upper Cretaceous period and Missouri limestone and shale of the Pennsylvanian period.

Cass County is drained by the Missouri River and its tributaries. The principal drainage systems in the county are shown in figure 13.

The East Nishnabotna River, Turkey Creek, and their tributaries drain more than half of the county; Seven Mile Creek and the West Nodaway River and their tributaries drain the rest. The channels of these creeks and rivers originally meandered in some places, but they have been straightened to reduce flooding.

The East Nishnabotna River begins in Audubon County to the north and enters Cass County at about the middle part of its northern border. It leaves the county in the southwest corner of Cass Township. Turkey Creek rises a few miles east of the northeast corner of the county and flows southwestward to join the East Nishnabotna River in the northern part of Cass Township. Indian Creek, which is near the western border of the county, enters Cass County in the northwest corner and empties into the East Nishnabotna River about 2½ miles west of Lewis. It drains the areas between the East Nishnabotna River and the East Fork of the West Nishnabotna River. Both Seven Mile Creek and the West Nodaway River originate in Cass County. They both leave the county in Noble Township, where they are about 3 miles apart.

Water Supply

On most farms in the county, water for domestic use and for livestock comes from wells. These wells are dug or drilled 30 to 248 feet deep (*25*). In the river valleys an abundant supply of water is obtained from sand points driven 40 feet deep into the sand underlying the river beds. In most years the wells are deep enough to furnish ample water, but the shallow wells are likely to go dry during droughts. Farm ponds are a reserve source of water for livestock on a few farms, and on some farms streams are a supplemental source of water.

The town of Atlantic has a municipal water system and obtains its water from wells along the East Nishnabotna River. Most of the other towns in Cass County also have municipal water supplies.

Climate [5]

The inland location of Cass County gives it a stimulating continental climate. Changes in weather are frequent and often pronounced. This is mainly because the county is near two major storm tracks—one from the southwest and the other from the northwest.

Summers are warm and winters are cold, but prolonged periods of extreme heat or intense cold are rare. Sunny skies and southerly winds prevail in summer. Winters are somewhat cloudy, and the prevailing winds are from the northwest. Minimum temperatures vary somewhat throughout the county, particularly on calm, clear nights when farm lowlands may have a temperature several degrees lower than that of the uplands or of urban areas. The amount of moisture received from showers varies considerably over short distances, but the seasonal total is about the same throughout the county. Otherwise, variations in climate are slight, and the Atlantic record, summarized in table 8, is representative of Cass County.

About 73 percent of the annual precipitation falls during the growing season, or from April through September. On the average, rain is most abundant in June and August. Measurable rainfall occurs on about 98 days a year, and 0.1 of an inch or more occurs on about 57 days in a year. Because growing corn requires about an inch of water a week, dry spells cause concern in some summers. Pro-

[5] Prepared by PAUL J. WAITE, State climatologist, U.S. Weather Bureau.

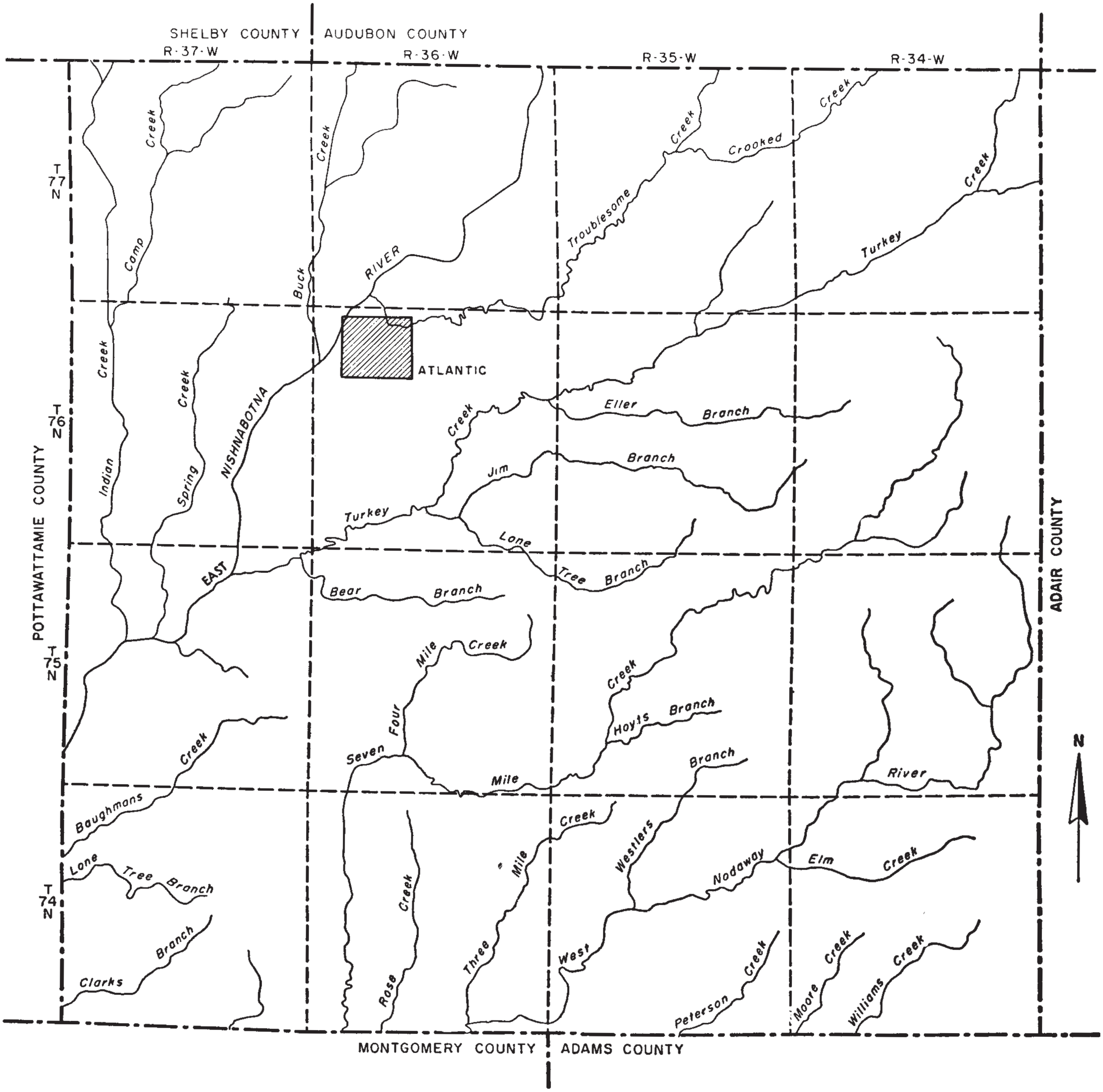

Figure 13.—Principal drainage systems in Cass County.

TABLE 8.—*Precipitation and temperature,*

[Based on a 30-year period

Month	Precipitation (in inches)								Temperature (°F.)		
	Average	Greatest daily		Snow, sleet					Average daily maximum	Average daily minimum	Average monthly
		Inches	Year	Average	Greatest monthly		Greatest daily				
					Inches	Year	Inches	Year			
January	1. 05	1. 24	1932	8. 1	33. 7	1936	10. 6	1932	31. 9	10. 6	21. 3
February	. 96	1. 43	1948	5. 6	17. 9	1939	11. 0	1945	36. 0	14. 9	25. 5
March	1. 85	2. 12	1946	7. 6	30. 4	1948	13. 0	1948	46. 3	24. 6	35. 5
April	2. 63	2. 25	1941	1. 0	6. 9	1945	6. 9	1945	62. 7	37. 1	49. 9
May	4. 00	2. 78	1946	. 1	2. 0	1945	2. 0	1945	73. 6	48. 5	61. 1
June	4. 85	3. 80	1941	0	0	------	0	------	82. 8	58. 9	70. 9
July	3. 44	5. 35	1948	0	0	------	0	------	88. 9	62. 9	75. 9
August	4. 62	4. 51	1935	0	0	------	0	------	86. 4	61. 5	74. 0
September	3. 31	3. 15	1958	0	([4])	1942	([4])	1942	78. 4	51. 8	65. 1
October	1. 99	3. 78	1931	([4])	0. 9	1932	. 9	1932	67. 6	40. 5	54. 1
November	1. 64	2. 79	1931	2. 8	12. 5	1957	10. 0	1957	48. 8	26. 2	37. 5
December	. 84	1. 49	1941	4. 4	13. 4	1951	5. 5	[2] 1940	33. 5	17. 0	25. 3
Year	31. 18	5. 35	1948	29. 6	33. 7	1936	13. 0	1948	61. 4	37. 9	49. 7

[1] Degree days based on 65° F. The heating degree-days for a day are determined by subtracting the average daily temperature from 65. These daily values are totaled to obtain the number of degree-days in a month. For example, to determine the average degree days for January in an 8-year period, total the degree-days for each January in that period and divide by eight.

longed drought is not common, however, and soil moisture reserves generally are adequate to supply crops with water even during dry spells. The chance of receiving an inch or more of rainfall per week during the critical growing period ranges from about 1 in 2 early in June to about 1 in 4 late in July. The approximate frequency of rains of stated duration and intensity is shown in table 9.

The largest amount of rainfall recorded in a day was 3.58 inches at Atlantic on August 30, 1922. Such a rainfall in 24 hours can be expected about once in every 40 years. Occasionally there are floods, most often in June from heavy rainfall or in February and March from snowmelt and rainfall. Overflow from the East Nishnabotna River has caused some of the most damaging floods in the county in the past 50 years.

About 50 thunderstorms occur in the average year, and 45 of these occur in the warmer 6 months of the year, during the growing season. The thunderstorms occasionally are accompanied by high wind, heavy rainfall, and hail. Tornadoes can be expected once or twice about every 5 years.

The average amount of snowfall received in the county is about 30 inches a year. In the season of 1911–1912, however, 66 inches of snow fell, and in the season of 1921–1922 only 4.4 inches fell. In about half the winters, the greatest daily snowfall is more than 7 inches. The average date of the first snowfall of an inch or more is December 5.

Temperatures vary markedly in Cass County throughout the year. The average coldest winter temperature is −20° F. In about half of the summers, the hottest temperature is about 100° or higher. A temperature of above 90° or higher, which is too hot for the best growth of most plants, occurs on an average of 35 days a year. A temperature of zero or colder occurs on an average of 16 days a year. The coldest temperature of record was −38° on January 19, 1892, and the hottest was 117° on July 25, 1936.

Table 10 shows the probabilities of the last freezing temperature in spring and the first freezing temperatures in fall in this county. It shows, for example, that there is a 10 percent chance of a temperature of 32° or lower occurring not later than April 18. That is, 9 years in 10, a temperature of 32° or lower will occur after April 18. The average date of the last temperature of 32° or lower in spring is May 4, and the average date of the first temperature of 32° or lower in fall is October 4, or a growing season of about 153 days.

Settlement and Population

Before settlement began in Cass County in 1833, the Pottawattamie Indians had encampments along many of the streams. Their main village was west of the present town of Lewis (*25*), where the Des Moines and Keokuk routes of the old Mormon Trail also joined. The county originally was part of Keokuk County, which extended westward to the Missouri River. In 1851 the present boundaries of the county were established and the county named in honor of Lewis Cass, United States Senator from Michigan. The first county seat was at Lewis, but in 1869 Atlantic became the county seat.

Mormons were among the first settlers in the county, and remnants of the old Mormon Trail are still visible near Seven Mile Creek. Another historical site is an old sandstone house on a hill near Lewis, which served as a part of the underground railway for runaway Negro slaves during the Civil War.

In 1960, according to the U.S. Census of Population, there were 17,919 people in Cass County. Of these, 6,890 lived in Atlantic; 1,233 lived in Anita; and 1,207 lived in Griswold. The combined population of the towns of Cumberland, Lewis, Marne, Massena, and Wiota was 1,782. Most of the remaining people lived on farms.

Atlantic Station, Cass County, Iowa

from 1931 through 1960]

Temperature (°F.)—Continued				Average degree days [1]	Average number of days with—				
Record high		Record low			Precipitation of 0.10 inch or more	Maximum temperature of—		Minimum temperature of—	
Degrees	Year	Degrees	Year			90° and above	32° and below	32° and below	Zero and below
65	1944	−29	1957	1, 352	3	0	15	30	7
69	1932	−34	1958	1, 109	3	0	11	27	4
86	1938	−31	1960	918	5	0	5	25	1
89	[2] 1960	6	1936	453	6	0	[3] 0	11	0
105	1934	24	1931	198	7	1	0	2	0
104	1933	36	[2] 1956	45	7	6	0	0	0
117	1936	43	1960	0	5	14	0	0	0
111	[2] 1936	34	1934	9	7	10	0	1	0
102	1939	22	1942	108	5	4	0	1	0
93	1953	11	[2] 1954	366	4	([3])	[3] 0	7	0
78	[2] 1953	−16	1952	825	3	0	3	21	([3])
69	1939	−22	1951	1, 184	2	0	11	29	4
117	1936	−34	1958	6, 567	57	35	45	154	16

[2] Also on earlier dates, months, or years.
[3] Less than one-half day.
[4] Trace.

TABLE 9.—*Frequency of rains of stated duration and intensity in Cass County, Iowa*

Frequency [1]	Duration of—						
	½ hour	1 hour	2 hours	3 hours	6 hours	12 hours	24 hours
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1 year	1. 1	1. 3	1. 6	1. 7	2. 0	2. 2	2. 6
2 years	1. 3	1. 6	1. 9	2. 1	2. 4	2. 8	3. 2
5 years	1. 7	2. 1	2. 5	2. 7	3. 1	3. 6	4. 1
10 years	1. 9	2. 5	2. 8	3. 1	3. 6	4. 2	4. 8
25 years	2. 2	2. 8	3. 3	3. 6	4. 1	4. 8	5. 4
50 years	2. 5	3. 2	3. 7	4. 0	4. 8	5. 4	6. 2
100 years	2. 8	3. 6	4. 1	4. 5	5. 2	6. 0	6. 8

[1] Expresses the frequency of the specified number of inches of rainfall at given time intervals. For example, 1.1 inches of rain can be expected to fall in one-half hour once each year (100 percent probability), but 2.8 inches can be expected to fall in one-half hour only once in 100 years (1 percent probability).

Community and Farm Facilities and Industries

Atlantic, the largest city in the county, is a modern city with excellent facilities for serving its residents. Many of the residents are active in promoting cultural and recreational events and in maintaining city-farm relationships.

The farms in Cass County generally have a substantial farmhouse and farm buildings. Most of the farms have electricity, running water, a telephone, automobiles, and modern farm equipment.

Educational facilities are available to all the children in the county through consolidated elementary schools and high schools. Schoolbuses transport the children to and from most of the schools. Rural mail reaches all farms in the county. A hospital provides health services, and churches of most denominations serve the county.

In Atlantic recreation is provided through golf courses, a city park, a swimming pool, and a theater. Fishing,

TABLE 10.—*Probabilities of last freezing temperatures in spring and first freezing temperatures in fall*

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 not later than	March 5	March 15	March 24	April 6	April 18
3 years in 10 not later than	March 14	March 25	April 2	April 15	April 27
5 years in 10 not later than	March 21	April 1	April 9	April 21	May 4
7 years in 10 not later than	March 28	April 8	April 16	April 26	May 10
9 years in 10 not later than	April 6	April 18	April 25	May 6	May 19
Fall:					
1 year in 10 earlier than	October 28	October 18	October 9	October 2	September 19
3 years in 10 earlier than	November 6	October 27	October 19	October 11	September 28
5 years in 10 earlier than	November 13	November 3	October 26	October 18	October 4
7 years in 10 earlier than	November 20	November 10	November 2	October 25	October 10
9 years in 10 earlier than	November 29	November 19	November 12	November 3	October 19

swimming, picnicking, and hiking can be enjoyed in Cold Springs State Park near Lewis and throughout the county.

The industries in Cass County are mainly those that process agricultural products. A major industry in Atlantic is a plant that produces animal feed and minerals. A research farm connected with this industry is a few miles south of Atlantic on U.S. Highway 6. A fairly large limestone quarry is on the western edge of Atlantic, and there are one or two smaller limestone quarries elsewhere in the county.

Transportation and Markets

Two railway systems serve the county. The main line of one crosses the county in an east-west direction, passing through Atlantic, Wiota, and Anita. A spur of the other comes from the south to Griswold, and another spur of the same railroad extends from Cumberland, through Massena, and goes eastward out of the county. In addition air transport is provided through services of the Atlantic Airport, which is about a mile west of Atlantic.

State, interstate, and county highways traverse the county. U.S. Highways 6 and 71, as well as several State highways, crisscross the county. When completed, Interstate Highway 80 will also pass through the county. There are also many gravel and blacktop roads. Thus, most farms in the county are near good all-weather roads that provide a way to markets and trading centers.

Beef cattle, hogs, and other livestock intended for slaughter generally are trucked to market at Omaha, Nebr., or to other livestock markets in Iowa and Missouri. Some beef cattle and feeder stock, however, are marketed through various community sale barns in several parts of the county. Corn and other grains are bought and sold through local grain dealers.

Agriculture

The agriculture of Cass County is based mainly on the production of corn, soybeans, oats, wheat, hay, and pasture and on the production and marketing of livestock and livestock products. The number of farms has been decreasing in recent years, but the size of the individual farms has increased. In the paragraphs that follow some facts about the agriculture are given. The statistics used are from the 1964 State of Iowa Annual Farm Census.

Farms and farm tenure.—The county had 1,615 farms in 1964. The total land in farms amounted to 356,036 acres, and the average size of the farms was 220 acres.

Full owners operated 55 percent of the land in farms in 1964. The remaining 45 percent of the land was rented by farm operators.

Crops and pasture.—Most of the cropland in Cass County is used for grain, which is fed to the livestock on the farms. Soybeans is the chief cash crop, but some corn also is sold. The soybeans are sold at elevators and then generally are shipped to markets in Iowa and Nebraska. The acreage of the principal crops grown in Cass County follows:

	Acres
Corn for all purposes	102,716
Oats	26,020
Soybeans	19,713
Hay, all	40,740
Alfalfa and alfalfa mixtures	24,860
Clover and timothy and mixtures of these	15,108
Small grains	576
Other hay cut	196

Oats, the second largest grain crop grown, is planted widely as a nurse crop for seedings of legumes and grasses. After the grain is harvested, the straw is baled and used as bedding for livestock on many of the farms.

Minor grains grown in the county are wheat, grain sorghum, popcorn, and barley. Wheat is often grown on poorly drained soils on low benches and bottom lands.

Hay crops are grown extensively in the cropping systems used on the farms. Most of the hay is fed to the livestock on the farms. The plants generally grown for hay are alfalfa, red clover, bromegrass, and orchardgrass.

In 1964 pasture occupied 96,459 acres in Cass County. Most of the pasture is on the steeper soils adjacent to the major streams and their tributaries. Large areas of pasture are in the southeast quarter of the county and in the northeast corner, where the terrain is rough. Many of the unimproved pastures consist of Kentucky bluegrass, and some consist of brushy cutover woodland. The improved pastures are made up of mixtures of legumes and grasses, such as alfalfa and bromegrass or of red clover or alsike clover and orchardgrass.

Livestock and livestock products.—The raising of livestock has always been important in Cass County. The principal kinds of livestock raised in Cass County and sold in 1964, were as follows:

Kinds of livestock:	*Number*
Grain-fed cattle sold	49,355
Grain-fed sheep and lambs	5,727
Calves born	18,074
Lambs born	3,173
Sows farrowing, fall	9,214
Sows farrowing, spring	14,129
Milk cows, 2 years old and older	3,259
Beef cows, 2 years old and older	15,943
Hens and pullets of laying age	149,619
Chickens	144,904
Turkeys	4,192

Feeding cattle for market is the most important livestock enterprise in the county. Many beef cowherds are maintained, and several of these are purebred herds. Dairy herds are also important, and the dairy products generally are marketed through local creameries.

Hogs are raised throughout the county, and some of the hogs are purebreds. The hogs are fed corn produced on the farms and are fattened for market at nearby packing centers.

Poultry also is important in Cass County, but the number of poultry raised has decreased in recent years.

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Glossary

Acidity. (See Reaction.)

Alluvium. Fine material, such as sand, silt, or clay, that has been deposited on land by streams.

Available moisture capacity. The difference between the amount of water in a soil at field capacity, and the amount in the same soil at the permanent wilting point. Commonly expressed as inches of water per inch depth of soil. (Also called moisture-holding capacity or water-holding capacity.)

Bottom land. The normal flood plain of a stream and the old alluvial plain that is seldom flooded. (See Bottoms, first, and Bottoms, second.)

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 (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay films. A thin coating of clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.

Concretions. Hard grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds that cement the soil grains together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are

Loose. Noncoherent; will not hold together in a mass.

Friable. When moist, crushes easily under gentle to moderate 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; tends to stretch somewhat and pull apart, rather than pull free from other material.

Hard. When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft. When dry, breaks into powder or individual grains under very slight pressure.

Cemented. Hard and brittle; little affected by moistening.

Contour tillage. Cultivation that follows the contour of the land, generally almost at right angles to the slope.

Flood plain. Nearly level land, consisting of stream sediment, that borders a stream and is subject to flooding unless protected artificially.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and it is therefore marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has (1) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. This layer, commonly called the soil parent material, is presumed to be like that from which the overlying horizons were formed in most soils. If the underlying material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Leaching, soil. The removal of materials in solution by the passage of water through the soil.

Moisture-holding capacity. See Available moisture capacity.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: fine, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. The weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Reaction, soil. The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction, because it is neither acid nor alkaline. In words the degree of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Sand. As a soil separate, individual rock or mineral fragments ranging from 0.05 to 2.0 millimeters in diameter. Most sand grains consist of quartz, but they may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Solum, soil. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in a 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 characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy,* (laminated), *prismatic,* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular,* Structureless soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer lying beneath the solum, or true soil; the C or R horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace (structural). An embankment or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. (See also clay, sand, and silt.) The basic textural classes, in order of increasing proportions of fine particles are as follows: sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water-holding capacity. See Available moisture capacity.

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