SOIL SURVEY OF

Madison County, Iowa

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa Agriculture and Home Economics Experiment Station

Major fieldwork for this soil survey was done in the period 1959–65. Soil names and descriptions were approved in 1968. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agriculture and Home Economics Experiment Station. It is part of the technical assistance furnished to the Madison County Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

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

Foresters and others can refer to the subsection "Woodland, Wildlife, and Recreation," where the soils of the county are grouped according to their suitability for trees.

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

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

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

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

Cover picture: Madison County is known in Iowa as the "Covered Bridge County." Alluvial land is near stream and bridge; Sloping stony land is on side slopes; and a Ladoga silt loam is on ridgetops behind the bridge.

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Issued June 1975

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SOIL SURVEY OF MADISON COUNTY, IOWA

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

MADISON COUNTY is in south-central Iowa (fig. 1). The county has a total area of 565 square miles, or 361,600 acres. Winterset, the county seat, is centrally located and is about 30 miles southwest of Des Moines and 30 miles northeast of Creston.

The county primarily is agricultural, but it has some of the largest open-pit lime quarries in the State. An important industry is the production of lime for agriculture and use in the production of cement, of crushed rock for road construction, and other uses. Industry and the labor supply are influenced by industrial growth in the capital city of Des Moines.

The principal crops are corn, soybeans, oats, and hay. Most grains and hay are fed to livestock. Beef cattle and hogs are the principal sources of income, but dairying and poultry also are important. Some corn is sold as grain, but soybeans are the only major cash crop.

Most soils of the county are productive, and they occupy a wide range of topography and landscape. In Iowa, Madison County is known as the "Covered Bridge County," having seven covered bridges in use on secondary roads. These offer a scenic and historical attraction for tourists and urban visitors.

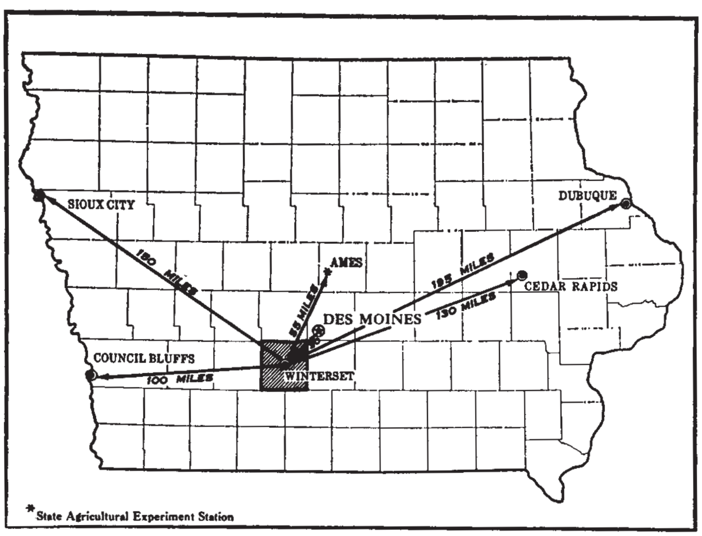

Figure 1.—Location of Madison County in Iowa.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Madison County, where they are located, and how they can be used.

The soil scientists went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. They observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots (*31*).[1]

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other 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. Macksburg and Winterset, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Lamoni clay loam, 5 to 9 percent slopes, is one of several phases within the Lamoni series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders,

[1] Italic numbers in parentheses refer to Literature Cited, p. 116.

trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from the aerial photographs.

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

Some mapping units are made up of soils of different series or of different phases within one series. One such kind of mapping unit shown on the soil map of Madison County is the soil complex. A soil complex consists of areas of two or more soils so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Clanton-Gosport silt loams, 9 to 14 percent slopes, moderately eroded, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Flaggy alluvial land is a land type in Madison County.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of readers, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. Then, 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 Madison County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

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

The five soil associations in Madison County are discussed in the following pages.

1. Macksburg-Winterset association

Nearly level and gently sloping, somewhat poorly drained and poorly drained soils that formed in loess on uplands

This association is in five areas in the county. The two larger areas are near Earlham and west of Winterset. The others are on broad divides south of Winterset, near Macksburg and Truro. A typical area is located 5 miles west of Winterset along State Highway 92 in Douglas and Lincoln Townships (fig. 2). The association makes up about 17.5 percent of the county.

Nearly all the soils in this association formed in loess. They are on broad, nearly level upland divides between the major streams. At the base of the longer slopes, there are some small areas of soils that formed in glacial till. The soils in this association formed under prairie grass, and most of them have a thick, dark surface layer that is high in organic-matter content. Available water capacity is high. Natural drainage is somewhat poor to poor.

The Macksburg soils occupy about 45 percent of the association, Winterset soils about 7 percent, and minor soils about 48 percent.

Macksburg soils are somewhat poorly drained. They have a thick, black silty clay loam surface layer that typically is not so thick as that of the Winterset soils. The subsoil is very dark grayish-brown and dark grayish-brown silty clay loam in the upper part and grayish brown in the lower part below a depth of about 30 inches. Yellowish-brown mottles are common below 30 inches.

Winterset soils are poorly drained. They have a thick, black silty clay loam surface layer. The upper part of the subsoil is very dark gray silty clay. Below a depth of about 25 inches, the subsoil ranges from dark grayish-brown to olive-gray light silty clay and silty clay loam. Olive-brown mottles are present in the subsoil.

Among the minor soils are Sharpsburg and Nira soils on the side slopes. Colo and Ely soils are closely intermingled in the drainageways. Small, depressed areas of the very poorly drained Sperry soils are on the broad upland flats. Small areas of Clearfield, Clarinda, and Lamoni soils occur near waterways, but their total acreage is small.

A diversified system of farming that emphasizes row crops is most commonly used in this association. Much of the grain is fed to livestock. Many operators prefer

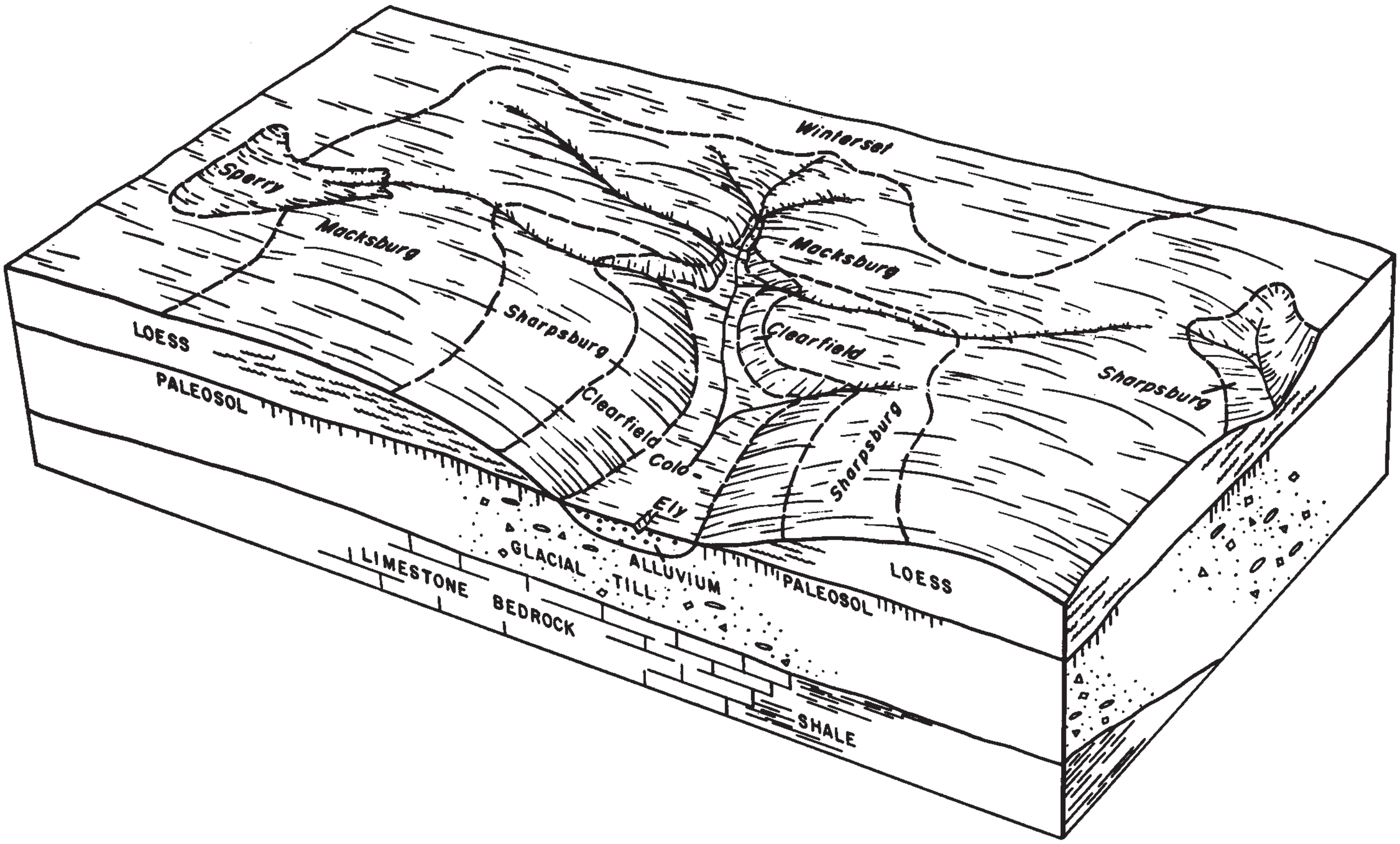

Figure 2.—**Relationship of soils and parent material in the Macksburg-Winterset association.**

cash crops of corn and soybeans. The more nearly level soils in this association are well suited to intensive cropping and produce above-average crop growth. These soils have high natural fertility and a deep root zone.

The soils in this association are generally well suited to row crops (fig. 3). Their main limitation as cropland is in areas of poor drainage. Most areas of the Winterset and Sperry soils require tile drains for best crop growth. Small areas of sloping soils are subject to slight to moderate erosion, and in these areas contour tillage or other erosion control practices are required to control soil loss if row crops are grown.

2. *Shelby-Sharpsburg association*

Moderately sloping to steep, moderately well drained soils that formed in glacial till and loess on uplands

This is the largest association in the county. It is characterized by high, narrow, rounded ridgetops, strongly sloping to steep side slopes, and narrow valleys (fig. 4). The side slopes are dissected by short waterways and small gullies. These drain into the larger, more stabilized drainageways (small creeks) forming the small valleys. These drainageways eventually merge with larger streams. A typical area is located three miles north of Macksburg. This association is mostly in the southern half of the county, but small areas occur in the northernmost tier of townships. The association makes up about 28 percent of the county.

In this association, most of the soils on side slopes formed in glacial till. The soils on ridgetops and adjacent side slopes formed in loess. Soils occupying approximately one-third of the acreage formed in loess, and those occupying two-thirds of the acreage formed in glacial till and alluvium (fig. 5, p. 6). All the soils formed under prairie vegetation. There is a wide range in physical characteristics and inherent fertility of soils in this association.

The Shelby soils occupy about 24 percent of the association, the Sharpsburg soils about 24 percent, and minor soils about 52 percent.

The Shelby soils formed in glacial till on the lower slopes. They typically have a very dark brown or very dark grayish-brown loam surface layer about 15 inches thick and a brown to dark yellowish-brown, firm clay loam subsoil.

The Sharpsburg soils formed in loess and are on ridgetops and short side slopes. They have a very dark brown silty clay loam surface layer about 11 inches thick. The subsoil is brown heavy silty clay loam in the upper part and is yellowish-brown light silty clay loam in the lower part.

On the steeper areas along some streams, Ladoga soils are on ridgetops and Gara soils are on side slopes. These soils formed under a mixed vegetation of prairie grasses and trees. Small areas of timberland and areas cleared of timber are common.

Figure 3.—Corn and soybeans are the major crops grown in the Macksburg-Winterset association.

Many other minor soils are common and locally important, but their total acreage is small. Nira, Clearfield, and Macksburg soils formed in loess. Soils formed in glacial till are Clarinda, Lamoni, and Arbor soils. Colo, Zook, and Kennebec are common soils on bottom land. Olmitz soils are on foot slopes and formed in loamy alluvium sediments.

General livestock farming is most common in this association. Emphasis is on the raising and feeding of beef cattle (fig. 6, p. 7). A considerable amount of grain is produced, but very little is sold. Most farmers need to buy additional grain to fatten stock for market. Larger farms are required for profitable units than in soil associations 1 and 3. The value of farmland ranges from low to moderately high.

The soils occupying ridgetops are fertile and are well suited or moderately suited to crops, but many of the glacial-till soils are suitable only for pasture. A wide range of cropping systems and management is used. Drainage in most places is good, but sidehill seeps are common. Wet areas occur in the narrow bottom lands and at the heads of drainageways. Erosion is a major hazard and ranges from slight to severe. Terraces or other erosion control measures are needed to control soil loss if row crops are grown.

3. Sharpsburg-Lamoni association

Nearly level to strongly sloping, moderately well drained and somewhat poorly drained soils that formed in loess and glacial till on uplands

This is the second largest soil association in the county. It lies in an irregular pattern north of the Middle River. A representative area is located four miles northwest of Pitzer in Jackson Township (fig. 7, p. 8).

The general topography is one of level to gently sloping ridgetops that have long, moderately to strongly sloping side slopes (fig. 8, p. 9), that break rather abruptly to strongly sloping to moderately steep areas near streams and tributaries. There are many long drainageways, and the slope patterns are irregular. The association makes up 25.5 percent of the county.

On about one-half to two-thirds of the acreage in this association, the soils formed in loess on ridgetops and upper side slopes. The glacial till in this part of the county is thinner than it is in the southern part. The till is underlain by shale and limestone bedrock; consequently, on the lower slopes there are soils of both glacial and residual origin. Most of the soils formed under grass vegetation, and most of them have a dark surface layer that is moderately high in organic-matter content. The

Figure 4.—**Typical area in Shelby-Sharpsburg association. Colo-Ely silty clay loams are in foreground; Shelby soils are on side slopes; and Sharpsburg soils are on ridgetops in background.**

soils on the ridgetops and adjacent slopes are somewhat poorly drained to moderately well drained. Narrow bands of wet seepy soils occur near the boundary zone of soils formed in loess and soils formed in till.

The Sharpsburg soils occupy about 55 percent of the association, Lamoni soils about 20 percent, and minor soils about 25 percent.

Sharpsburg soils formed in loess; they have a very dark brown silty clay loam surface layer about 11 inches thick. The subsoil is yellowish-brown heavy silty clay loam that grades to light silty clay loam in the lower part.

Lamoni soils are the major soils in the association that formed in glacial till. Lamoni soils typically have a black clay loam surface layer about 11 inches thick and a grayish-brown, firm heavy clay loam subsoil that is mottled with brown.

Minor soils that formed in loess are Winterset, Macksburg, and Clearfield soils. Clarinda and Shelby soils formed in glacial till. Some areas of Clanton and Gosport soils, which formed in material from shale, and some areas of Nordness soils, which formed in material from limestone bedrock, occur near streams. Colo, Kennebec, and Zook soils are common on the bottom lands.

Most of the farming is diversified. Grain and livestock are the main products. There are some cash grain farms, but most of the grain is fed to livestock. Soybeans are an important cash crop. The value of the farmland is moderately high to high.

Most soils in this association are suited to cultivation, but more sloping areas are better suited to pasture. The natural fertility is high in the soils derived from loess and moderate to low in the soils formed in glacial till. Erosion is slight to severe, and control of erosion is the major concern of management. Terraces or other erosion control measures are needed to control soil losses if row crops are grown. Wetness from seeps in the loess-glacial till boundary zone of side slopes delays tillage and reduces crop growth in many places.

4. *Clinton-Lindley-Steep rock land-Clanton association*

Strongly sloping to very steep, moderately well drained soils that formed in loess and glacial till; and very slowly permeable, droughty soils that formed in shale on uplands

This association extends across the county in areas along Middle River and North River and along Clanton Creek and Jones Creek. A representative area is in Pammel State Park, 5 miles southwest of Winterset along

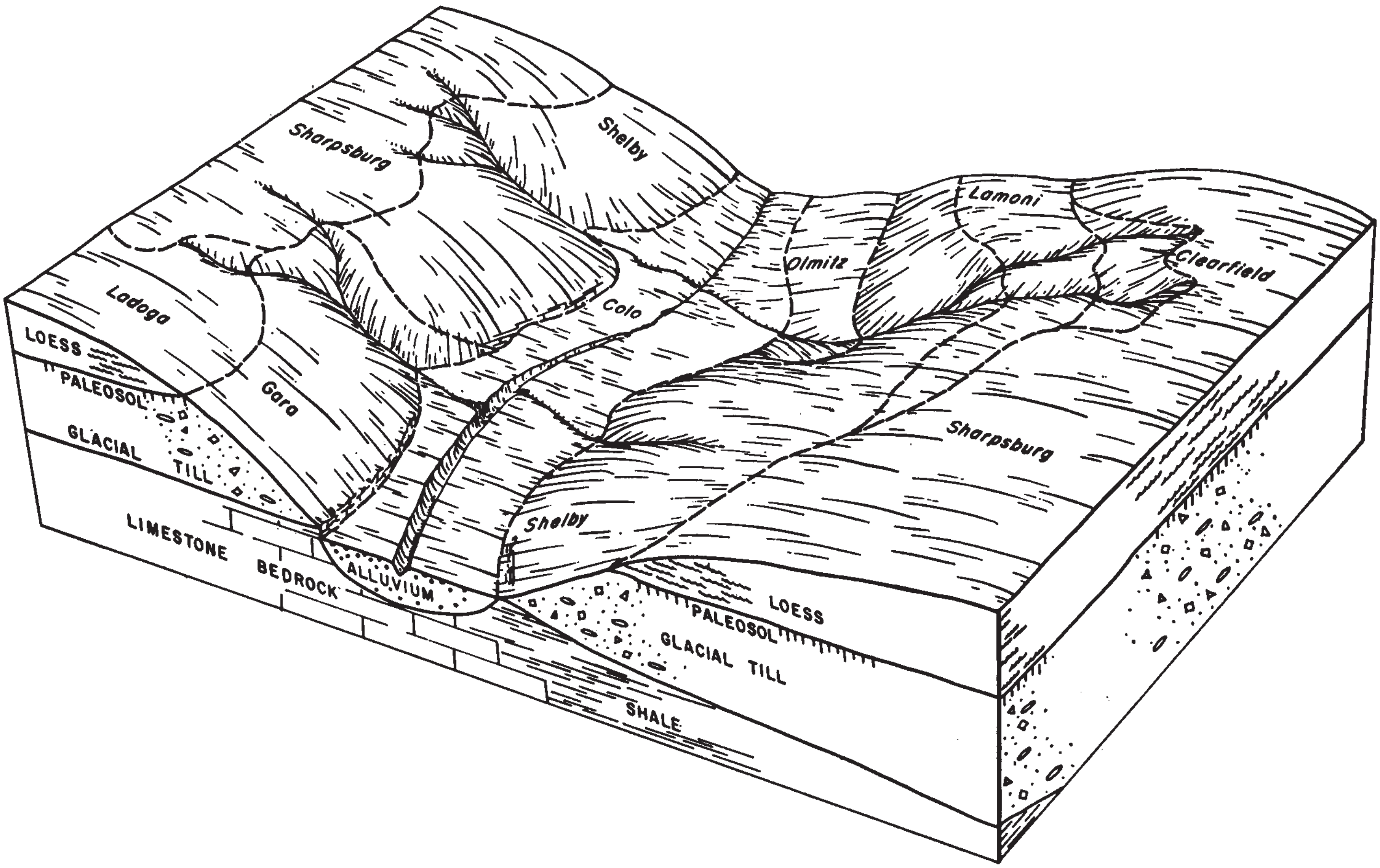

Figure 5.—**Relationship of soils and parent material in the Shelby-Sharpsburg association.**

Middle River (fig. 9, p. 10). The association makes up about 23 percent of the county.

In the central part of the county, Middle River, North River, and lower Cedar Creek have cut through the limestone and have exposed layers of red, gray, and brown shale. Steep talus slopes have formed below limestone and shale ledges. Some lower slopes are underlain by shale, forming benches covered by loess or glacial materials. Where lime rock is exposed farther downslope, large benches are underlain by limestone.

Throughout the area, rock ravines extend back from main streams. Where the rock ledges have not crumbled away between ravines, they support long, narrow ridges that have, on their crests, soils formed in loess or in glacial till. These ridges have very steep side slopes of rock, and rapidly moving water carries many fragments of limestone downslope, where they are spread out and mixed in narrow stream bottoms.

The steep slopes and bedrock outcrops in this association form a sharp boundary with the less sloping and rounded hillsides of adjacent associations. Toward the eastern part of the county, the limestone layer becomes thinner and ends just east of Peru. Farther east, there are layers of shale and the slopes, though steep, are more regular and rounded.

Clinton soils occupy about 13 percent of the association, Lindley soils about 7 percent, Steep rock land about 7 percent, Clanton soils about 4 percent, and minor soils about 69 percent.

Clinton soils have a very dark grayish-brown silt loam surface layer about 4 inches thick, a platy, brown subsurface layer about 4 inches thick, and a dark yellowish-brown light silty clay and silty clay loam subsoil.

Lindley soils typically have a very dark gray loam surface layer about 5 inches thick, a platy, grayish-brown loam subsurface layer about 4 inches thick, and a brown and yellowish-brown, firm clay loam subsoil.

Steep rock land consists mainly of steep limestone outcrops and ledges of limestone and sandstone.

Clanton soils have a dark reddish-brown silt loam surface layer about 8 inches thick, a platy, reddish-brown subsurface layer about 3 inches thick, and a reddish-brown, very firm silty clay subsoil. They are underlain by shale.

Minor soils occupy many narrow drains and bottom lands not included in the Zook-Wabash-Nodaway association. These are mainly the Colo, Kennebec, Nodaway, and Zook soils; Colo-Ely silty clay loams; Flaggy alluvial land; and Spillville loam and Spillville loam, flaggy substratum. Nordness, Martinsburg, Hixton, Ladoga, Clinton, Givin, Gosport, and Gara soils, and Sloping stony land are minor soils of the uplands.

Nearly all of this association is unsuitable for crops. Almost one-fourth of it supports stands of oak and other

***Figure 6.*—Herds of beef cattle are common in the Shelby-Sharpsburg association. Pond in background is for gully control and stock watering.**

hardwoods. Only on bottom lands, narrow cleared ridges, and high benches or uplands can crops be grown. Yields are typically lower than in other associations. Land values vary widely but average much lower than in other associations of the county.

Though its use for farming is severely limited, this association has considerable scenic value. Roads wind through wooded country along ridgetops or stream bottoms. Layers of limestone and shale are exposed in some places. Both the Winterset City Park and Pammel State Park, which has a tunnel cut through solid limestone, are in this association. There are several large, open pits where limestone is or has been quarried. Seven covered bridges add considerably to the picturesque nature of the countryside.

5. Zook-Wabash-Nodaway association

Nearly level, moderately well drained to very poorly drained soils that formed in alluvium on bottom lands

This association consists of nearly level soils on bottom lands (fig. 10, p. 11). Nearly all the soils formed in alluvium. Some of the higher benches are covered by a thin layer of loess. This association is separated from other associations on the general soil map where the bottom lands are more than 1 mile in width. It lies along North River, Middle River, and Clanton Creek. Narrower bottom lands are included in the other associations as minor soils. A representative area is located just east of the town of Patterson (fig. 11, p. 11). This association makes up 6 percent of the county.

Zook soils occupy about 40 percent of the association, Wabash soils about 15 percent, Nodaway soils about 10 percent, and minor soils about 35 percent.

Zook and Wabash soils are similar in that they are black or very dark gray in color to a depth of 40 inches or more. They differ mainly in their clay content. Wabash soils are silty clay or clay. Zook soils have somewhat less clay and are heavy silty clay loam or light silty clay. Zook soils are poorly drained, and Wabash soils are very poorly drained. Nodaway soils are very dark grayish-brown and grayish-brown, stratified silt loam soils that have thin lenses of sandy loam or loam in places. They are moderately well drained.

Among the minor soils are the Bremer, Colo, Nevin, Vesser, and Wiota soils, all of which are on low benches or second bottoms. The Kennebec and Nodaway soils generally occur nearest the stream channel, and they are

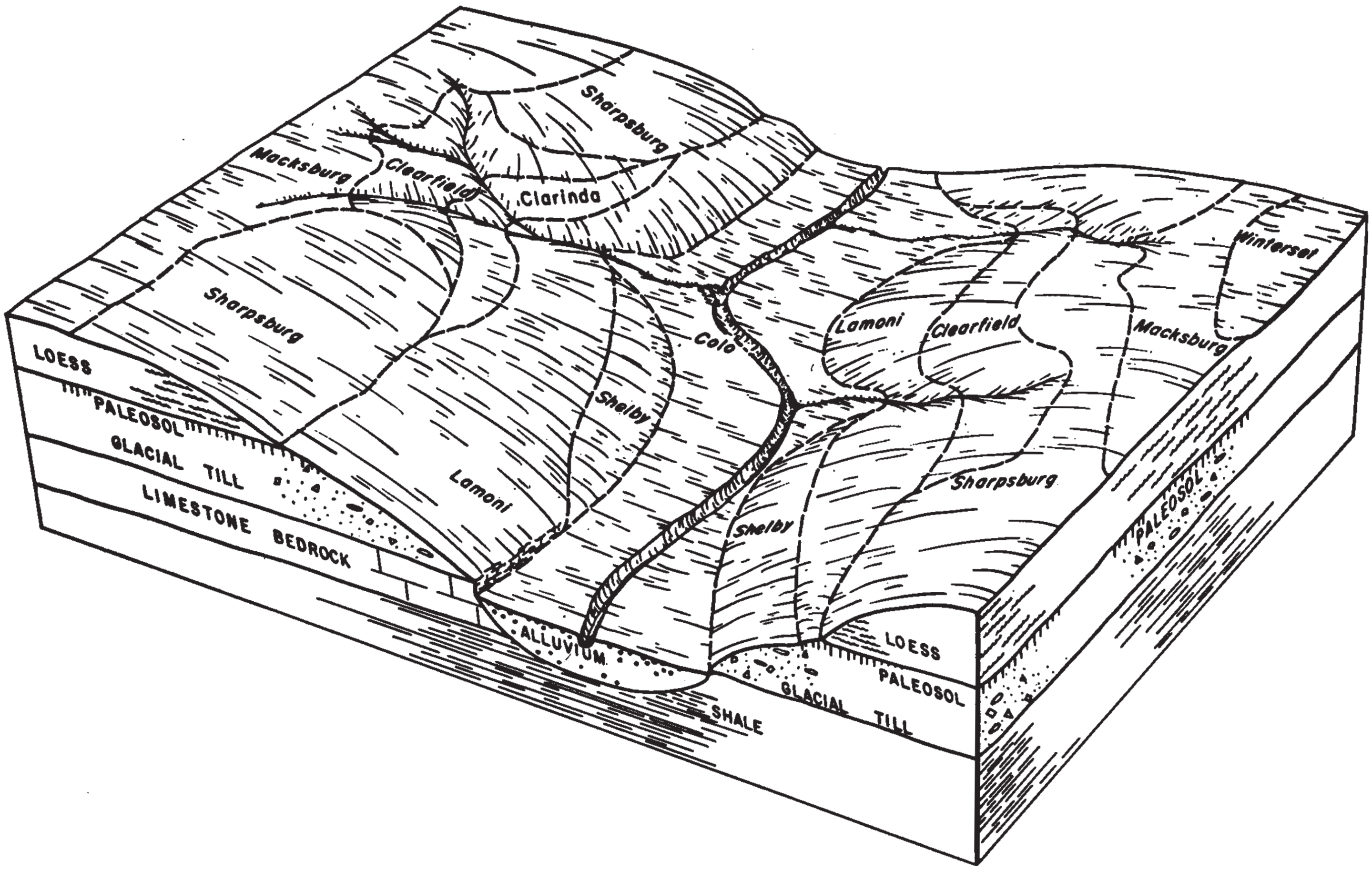

Figure 7.—**Relationship of soils and parent material in the Sharpsburg-Lamoni association.**

more subject to flooding than the other soils in the association. However, their natural drainage is much better than that of the Zook or Wabash soils.

Most areas of the soils in this association are in corn and soybeans. Some livestock is fed, but much of the grain is sold. Land values are high, and farms do not need to be large to make economical units. A few areas are still wooded and some small areas that flood frequently are suited to pasture.

The available water capacity of the major soils is moderate or high. Flooding is the main concern of management in some places. Many areas need drain tile and surface drainage if satisfactory crop growth is to be obtained.

Descriptions of the Soils

This section describes the soil series and mapping units of Madison County. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

Each soil series is described and contains both a short description of a representative soil profile and a much more detailed description of the same profile that scientists, engineers, and others can use in making highly technical interpretations. The description of each series includes a brief statement of the range in characteristics of the soils in the series, as mapped in this county. Following the series description, each mapping unit in the series is described individually. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. Miscellaneous land types, such as Flaggy alluvial land, are described in alphabetic order along with the soil series.

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

For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils in the county are described. Many terms used in the soil descriptions and other sections are defined in the Glossary.

Figure 8.—**Typical landscape in the Sharpsburg-Lamoni association. Sharpsburg soils are on side slopes, and Lamoni soils are downslope near farm ponds and near trees and brush.**

Alluvial Land

Alluvial land (0 to 2 percent slopes) (Au) is near major streams that have fairly stable banks. Slopes range to 3 percent along depressions and side drains. The streams and meandering side drains do not severely limit use. Alluvial land is adjacent to the Nodaway, Kennebec, or Colo soils, which are farther away from the streams, and it typically includes many small areas of these soils. Some large, densely timbered areas include large areas of other alluvial soils.

In most places this land type has a light-colored, silty or sandy surface layer. Below this is a stratified mixture of sand, silt, and clay. Alluvial land is often wet because of frequent flooding. It has a wide range in permeability, texture, and natural drainage.

This land type is suited to row crops, but there is a wide range of fertility within individual areas. Frequent flooding, drainage, accessibility, and cost of tree removal severely limit use for crops (fig. 12, p. 13). If wetness and flooding can be feasibly controlled, this land type can be row cropped often with good results. Many areas are used for pasture. Use for wildlife habitat or recreation is practicable in some areas. (Capability unit IIIw-4; woodland suitability group 2)

Alluvial Land, Channeled

Alluvial land, channeled (0 to 2 percent slopes) (Av) is near meandering streams that have changing channels and stream bank erosion. Slopes range to 4 percent on short side slopes along the drains and depressions. This land type is dissected by numerous noncrossable side drains and streams and by old depressions and bayous. Some of these are filled with water or are marshy. This land type is adjacent to the Nodaway, Kennebec, and Colo soils, which are farther away from the streams, and includes small areas of these soils. It includes the main channel and along larger streams contains many sand bars and riverwash areas.

This land type generally has a light-colored sandy loam to loamy sand surface layer. Below this is a stratified mixture of silt, sand, or clay. Alluvial land, channeled, is generally wet because of frequent flooding and pond-

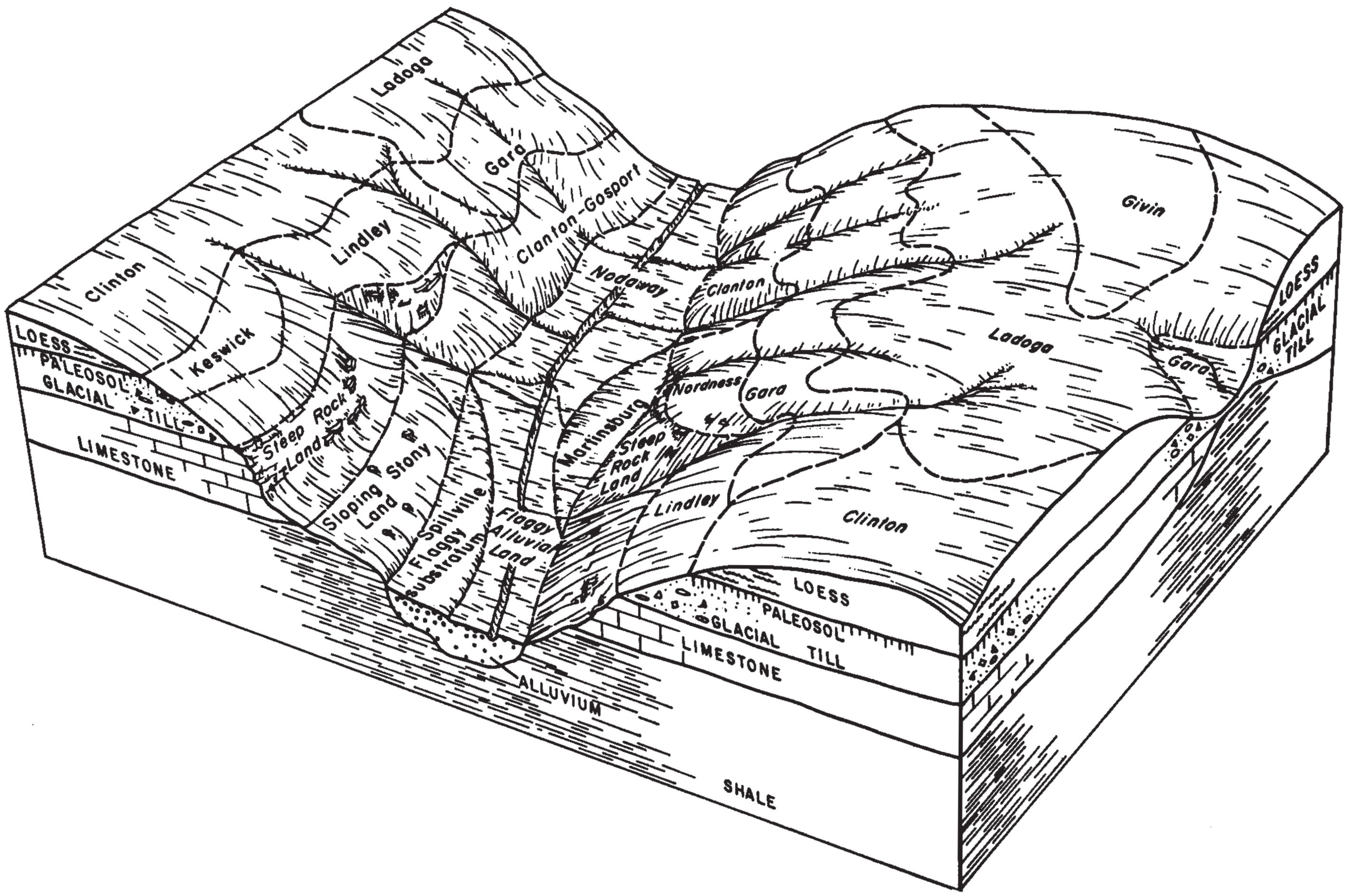

Figure 9.—**Relationship of soils and parent material in the Clinton-Lindley-Steep rock land-Clanton association.**

ing. Frequent flooding scours out new drains or deposits new materials, changing the shape and composition of this land type from year to year.

Most areas are in trees and wooded pasture, but some are idle. This land is not suited to row crops and has severe limitations for pasture. Pasture yields are poor. Other possible uses are for wildlife habitat, recreational purposes, or improved woodland. (Capability unit Vw–1; woodland suitability group 2)

Arbor Series

The Arbor series consists of deep, dark-colored, moderately well drained soils that formed in loamy sediments and glacial till. These soils are on high foot slopes but extend to the base of the slopes. They are on uplands in the southwestern part of the county. They are downslope from the Lamoni and Shelby soils. In some areas they are upslope from and adjacent to the less sloping Ely and Olmitz soils. Slopes range from 9 to 14 percent. They are more uniform and, in most places, less steep than those of the adjacent Shelby soils. The native vegetation is prairie grasses.

In a representative profile, the surface layer is very dark brown loam about 14 inches thick. The upper part of the subsoil is very dark grayish-brown and dark grayish-brown, friable light clay loam about 9 inches thick. It has some yellowish-brown mottling. The lower part of the subsoil is yellowish-brown clay loam mottled with yellowish brown and grayish brown. It extends to a depth of about 43 inches. The substratum is yellowish-brown, massive clay loam till. Mottling increases with depth.

The Arbor soils have high available water capacity. Permeability is moderate in the surface layer and subsoil but is moderately slow in the underlying till. These soils have a deep, favorable root zone. They are medium acid in the surface layer unless limed and range from medium to high in organic-matter content. They are low in available nitrogen and available phosphorus and medium in available potassium.

Arbor soils commonly are used for row crops, but they occur in small areas and normally are managed with adjacent soils. Arbor soils are subject to erosion. Their use for crops or pasture depends on the kinds of associated soils upslope or on the shape of the individual areas.

Representative profile of Arbor loam, 9 to 14 percent slopes, 2,200 feet south and 140 feet west of the northeast corner of sec. 3, T. 75 N., R. 29 W., in a cultivated field on a north-facing upland slope of 10 percent:

Ap—0 to 7 inches, very dark brown (10YR 2/2) heavy loam; dark gray (10YR 4/1) when dry; cloddy; weak, very

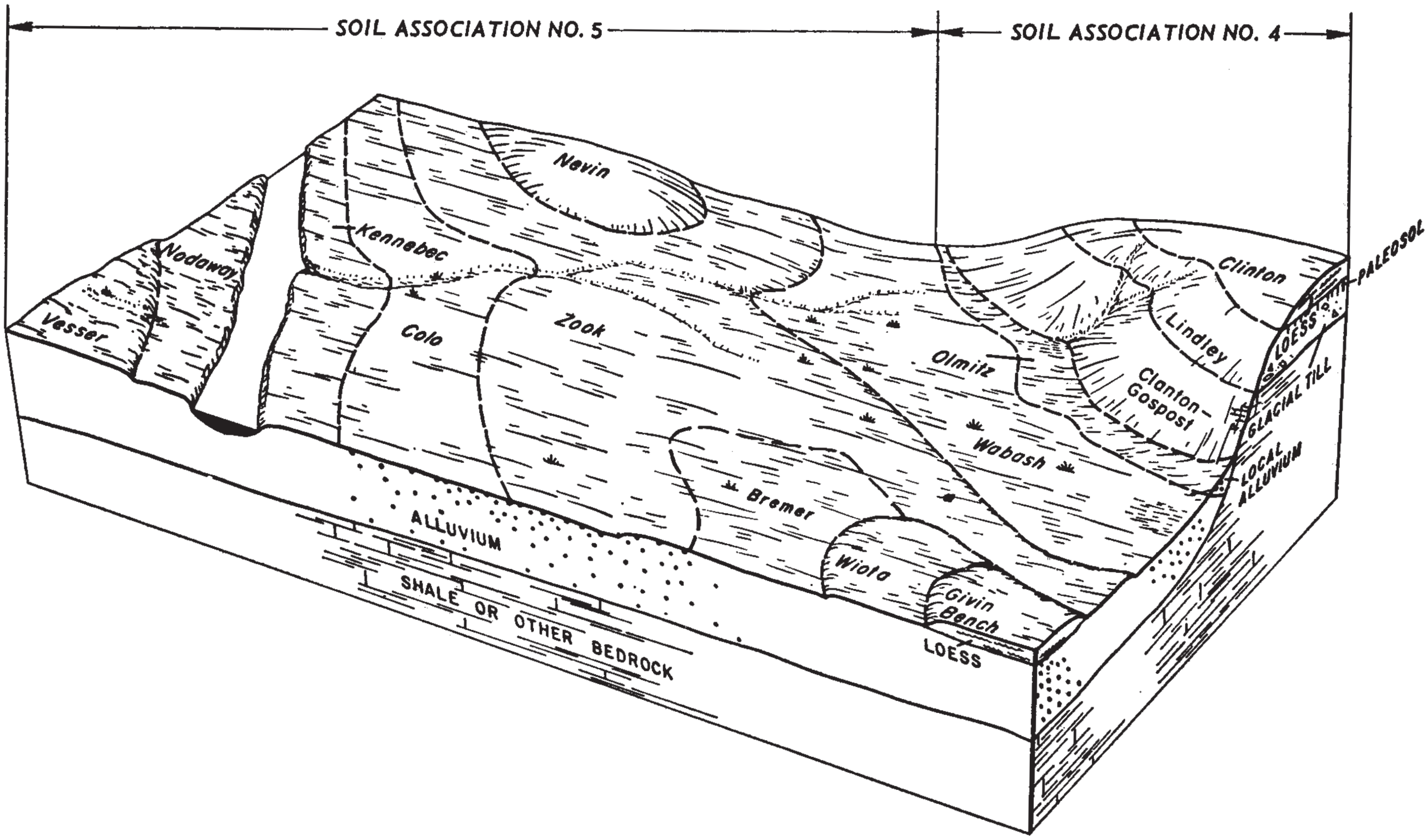

Figure 10.—**Relationship of soils and parent material in the Zook-Wabash-Nodaway association.**

Figure 11.—**Nearly level bottom land along the Middle River east of Patterson. Colo and Zook soils are on most bottom lands in this area.**

fine, subangular blocky structure; friable; plentiful roots; medium acid (pH 5.8); clear, smooth boundary.

A1—7 to 14 inches, very dark brown (10YR 2/2) loam; color same as matrix when kneaded; dark gray (10YR 4/1) to dark grayish brown (10YR 4/2) when dry; weak, fine, granular structure; friable; plentiful roots; medium acid (pH 5.6); clear, smooth boundary.

B1—14 to 23 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) light clay loam; few, fine, distinct, yelowish-brown (10YR 5/4) mottles; weak, medium, subangular blocky structure, breaking to weak, medium, granular structure; friable; few fine pores; few very dark gray (10YR 3/1) coatings; plentiful roots; medium acid (pH 5.6); gradual, smooth boundary.

IIB2t—23 to 34 inches, yellowish-brown (10YR 5/6) clay loam; faces of peds brown (10YR 5/3) to yellowish brown (10YR 5/4); few, fine, faint, yellowish-brown (10YR 5/8) and pale-brown (10YR 6/3) mottles; weak to moderate, medium, subangular blocky structure; firm; thin, nearly continuous clay films; few dark coatings along some vertical ped faces and root channels in upper part of horizon; few, dark oxide stains; common pebbles and stones; few fine pores; few roots; medium acid (pH 6.0); gradual, smooth boundary.

IIB3t—34 to 43 inches, yellowish-brown (10YR 5/6) clay loam; faces of peds yellowish brown (10YR 5/4); common, fine, faint, grayish-brown (10YR 5/2) mottles; weak, coarse, subangular blocky structure; firm; thin, discontinuous clay films on some ped faces; few pebbles and stones; many, fine, dark oxide stains; few roots; neutral (pH 6.8); clear, smooth boundary.

IIC—43 to 50 inches, yellowish-brown (10YR 5/4 and 5/6) clay loam; few, fine, faint, yellowish-brown (10YR 5/8) mottles; massive; firm; few pebbles; few, dark oxide stains; no roots; neutral (pH 6.8).

The loamy sediments range from 18 to 36 inches in thickness and form both the surface layer and the upper part of the subsoil. The surface layer ranges from 10 to 20 inches in thickness and grades gradually to very dark grayish brown to brown in the upper part of the subsoil. The subsoil is 10 inches to about 30 inches thick and is grayish brown to yellowish brown in the lower part. In some places only yellowish-brown mottling occurs in the subsoil. The subsoil ranges from heavy loam to clay loam. Stones and pebbles occur in the lower part of the subsoil and in the substratum. Depth to carbonates ranges from 48 to 60 inches.

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

Soil	Acres	Percent
Alluvial land	3,503	1.0
Alluvial land, channeled	810	.2
Arbor loam, 9 to 14 percent slopes	895	.2
Bremer silty clay loam	840	.2
Caleb loam, 9 to 14 percent slopes, moderately eroded	395	.1
Caleb-Mystic loams, 9 to 14 percent slopes, moderately eroded	765	.2
Caleb-Mystic loams, 14 to 18 percent slopes, moderately eroded	274	.1
Clanton silt loam, 9 to 14 percent slopes, moderately eroded	144	(1)
Clanton silt loam, 14 to 25 percent slopes, moderately eroded	491	.1
Clanton-Gosport silt loams, 9 to 14 percent slopes, moderately eroded	262	.1
Clanton-Gosport silt loams, 14 to 18 percent slopes, moderately eroded	500	.1
Clanton-Gosport silt loams, 18 to 25 percent slopes, moderately eroded	2,696	.7
Clanton-Gosport silt loams, 25 to 40 percent slopes, moderately eroded	1,313	.4
Clarinda silty clay loam, 5 to 9 percent slopes	855	.2
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	527	.1
Clearfield silty clay loam, 5 to 9 percent slopes	4,280	1.2
Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded	3,047	1.0
Clinton silt loam, 2 to 5 percent slopes	1,465	.4
Clinton silt loam, 5 to 9 percent slopes	503	.1
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	5,337	1.5
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	3,164	1.0
Clinton silt loam, benches, 2 to 5 percent slopes	394	.1
Colo silty clay loam	2,260	.6
Colo silty clay loam, channeled	282	.1
Colo-Ely silty clay loams, 2 to 5 percent slopes	6,686	1.8
Colo-Ely silty clay loams, gullied, 2 to 5 percent slopes	12,368	3.4
Dunbarton silt loam, deep variant, 9 to 14 percent slopes, moderately eroded	367	.1
Ely silty clay loam, 2 to 5 percent slopes	2,731	.8
Flaggy alluvial land	711	.2
Gara loam, 5 to 9 percent slopes, moderately eroded	131	(1)
Gara loam, 9 to 14 percent slopes, moderately eroded	4,224	1.2
Gara loam, 14 to 18 percent slopes	390	.1
Gara loam, 14 to 18 percent slopes, moderately eroded	14,935	4.1
Gara loam, 18 to 25 percent slopes, moderately eroded	14,709	4.1
Gara loam, 25 to 40 percent slopes	2,095	.6
Givin silt loam	450	.1
Givin silt loam, benches	461	.1
Gosport silt loam, 14 to 18 percent slopes	211	.1
Gosport silt loam, 18 to 25 percent slopes	330	.1
Hixton fine sandy loam, 20 to 40 percent slopes	339	.1
Judson silty clay loam, 2 to 6 percent slopes	373	.1
Kennebec silt loam	4,438	1.2
Keswick loam, 9 to 14 percent slopes, moderately eroded	693	.2
Ladoga silt loam, 2 to 5 percent slopes	6,797	1.9
Ladoga silt loam, 2 to 5 percent slopes, moderately eroded	624	.2
Ladoga silt loam, 5 to 9 percent slopes	1,369	.4
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	23,784	6.6
Ladoga silt loam, 9 to 14 percent slopes	454	.1
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	7,503	2.1
Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	155	(1)
Ladoga silt loam, benches, 2 to 5 percent slopes	1,164	.3
Lamoni clay loam, 5 to 9 percent slopes	399	.1
Lamoni clay loam, 5 to 9 percent slopes, moderately eroded	1,368	.4
Lamoni clay loam, 9 to 14 percent slopes	885	.2
Lamoni clay loam, 9 to 14 percent slopes, moderately eroded	17,655	4.9
Lamoni clay loam, 9 to 14 percent slopes, severely eroded	706	.2
Lindley loam, 9 to 14 percent slopes, moderately eroded	231	.1
Lindley loam, 14 to 18 percent slopes, moderately eroded	1,465	.4
Lindley loam, 18 to 25 percent slopes	1,623	.4
Lindley loam, 25 to 40 percent slopes	2,273	.6
Lindley soils, 14 to 18 percent slopes, severely eroded	833	.2
Macksburg silty clay loam, 0 to 2 percent slopes	22,004	6.1
Macksburg silty clay loam, 2 to 5 percent slopes	9,640	2.7
Martinsburg silt loam, 2 to 5 percent slopes	268	.1
Mystic loam, 9 to 14 percent slopes, moderately eroded	331	.1
Mystic-Clanton complex, 9 to 14 percent slopes, moderately eroded	202	(1)
Mystic-Clanton complex, 14 to 18 percent slopes, moderately eroded	395	.1
Nevin silty clay loam, 0 to 2 percent slopes	1,331	.4
Nevin silty clay loam, 2 to 5 percent slopes	370	.1
Nira silty clay loam, 5 to 9 percent slopes, moderately eroded	2,161	.6
Nodaway silt loam	3,369	.9
Nodaway silt loam, channeled	543	.2
Nodaway-Martinsburg silt loams, 2 to 5 percent slopes	437	.1
Nordness loam, 15 to 25 percent slopes	2,007	.6
Olmitz loam, 2 to 5 percent slopes	1,101	.3
Olmitz loam, 5 to 9 percent slopes	1,136	.3
Sharpsburg silty clay loam, 0 to 2 percent slopes	3,187	.9
Sharpsburg silty clay loam, 2 to 5 percent slopes	36,420	10.1
Sharpsburg silty clay loam, 2 to 5 percent slopes, moderately eroded	639	.2
Sharpsburg silty clay loam, 5 to 9 percent slopes	7,834	2.2
Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	31,880	8.8
Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	1,340	.4
Sharpsburg silty clay loam, benches, 0 to 2 percent slopes	146	(1)
Sharpsburg silty clay loam, benches, 2 to 5 percent slopes	512	.1
Shelby loam, 9 to 14 percent slopes, moderately eroded	2,478	.7
Shelby loam, 14 to 18 percent slopes	509	.1
Shelby loam, 14 to 18 percent slopes, moderately eroded	6,597	1.8
Shelby loam, 18 to 25 percent slopes, moderately eroded	4,207	1.2
Shelby soils, 14 to 18 percent slopes, severely eroded	338	.1
Shelby-Lamoni complex, 5 to 9 percent slopes, moderately eroded	133	(1)

See footnote at end of table.

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

Soil	Acres	Percent	Soil	Acres	Percent
Shelby-Lamoni complex, 9 to 14 percent slopes	426	. 1	Vesser silt loam, 2 to 5 percent slopes	197	(1)
Shelby-Lamoni complex, 9 to 14 percent slopes, moderately eroded	9, 064	2. 5	Wabash silty clay	201	(1)
Shelby-Lamoni complex, 9 to 14 percent slopes, severely eroded	346	. 1	Wabash silty clay loam	3, 385	. 9
Shelby-Lamoni complex, 14 to 18 percent slopes, moderately eroded	8, 143	2. 3	Winterset silty clay loam	4, 711	1. 3
Shelby-Lamoni complex, 14 to 18 percent slopes, severely eroded	427	. 1	Wiota silt loam, 0 to 2 percent slopes	319	. 1
Sloping stony land	682	. 2	Wiota silt loam, 2 to 5 percent slopes	231	. 1
Sperry silt loam	411	. 1	Zook silty clay loam, 0 to 2 percent slopes	9, 211	2. 6
Spillville loam	334	. 1	Zook silty clay loam, 2 to 5 percent slopes	2, 389	. 7
Spillville loam, flaggy substratum	291	. 1	Made land	259	. 1
Steep rock land	6, 378	1. 8	Quarries	1, 165	. 3
Vesser silt loam, 0 to 2 percent slopes	389	. 1	Interstate 80	61	(1)
			Water	133	(1)
			Total	361, 600	100. 0

[1] Less than 0.1 percent.

Figure 12.—**Typical area of Alluvial land. Scattered fragments of wood have been deposited by floods.**

The Arbor soils formed in thinner loamy sediments than the Olmitz soils and are steeper on hillsides. They are more friable and less clayey in the upper part of the subsoil than the Shelby soils, which formed entirely in firm clay loam glacial till.

Arbor loam, 9 to 14 percent slopes (AwD).—This soil is not extensive and is in small areas on high foot slopes.

Included with this soil in mapping were small areas of Shelby and Olmitz soils. Also included in places were small areas of an eroded soil.

This Arbor soil is used for crops and pasture. It is in small, irregularly shaped areas that generally are managed with the adjacent soils. Soil tilth commonly is good. Erosion is a serious hazard if this soil is cultivated. It is moderately suited to row crops if erosion is controlled. In some places runoff from upslope concentrates and forms gullies. (Capability unit IIIe–1; woodland suitability group 4)

Bremer Series

The Bremer series consists of deep, dark-colored, poorly drained soils that formed in fine-textured alluvium along the major streams. These nearly level soils are on very low stream benches or second bottoms and are subject to flooding at times of very high water. They are adjacent to the Nevin soils on benches and the Colo, Wabash, and Zook soils on first bottoms. The native vegetation was water-tolerant prairie grasses.

In a representative profile, the surface layer is black silty clay loam about 19 inches thick. The subsoil is very dark gray, dark grayish-brown, and dark gray, firm silty clay loam that extends to a depth of about 50 inches. It is firmer than the surface layer and is mottled with light olive brown, grayish brown, and yellowish brown.

The Bremer soils have high available water capacity. Permeability is moderately slow. There is little surface drainage, so these soils dry out slowly. They are slightly acid in the surface layer unless limed and are high in organic-matter content. These soils are low in available nitrogen and medium to high in available phosphorus and potassium.

These soils are well suited to row crops if they have artificial drainage and if good management is used. Parts of some areas where water stands for long periods have a tendency to puddle, restricting root development and stunting crops. If drained, the Bremer soils have a deep, favorable root zone.

Bremer soils are in large areas, but in most places they are managed with the adjacent soils. Bremer soils are fertile, and most areas are used for crops. They have minor tillage problems in wet years.

Representative profile of Bremer silty clay loam, 845 feet north and 170 feet east of the southwest corner of sec. 12, T. 75 N., R. 28 W., on a nearly level second bottom:

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, fine, granular structure; friable; plentiful roots; slightly acid (pH 6.4); clear, smooth boundary.

A3—8 to 19 inches, black (N 2/0) silty clay loam; dark gray (10YR 4/1) when dry; weak, very fine, subangular blocky structure, breaking to weak, medium, granular structure; friable to firm; few tubular pores in peds; plentiful roots; slightly acid (pH 6.4); gradual, smooth boundary.

B21t—19 to 31 inches, very dark gray (N 3/0) heavy silty clay loam to light silty clay; very dark gray (10YR 3/1) when kneaded; dark gray (10YR 4/1) when dry; moderate, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; firm; few tubular pores in peds; few dark-brown (7.5YR 4/4) oxide concretions; thick, nearly continuous clay films on prism faces and thin, discontinuous clay films on blocky peds; plentiful roots; slightly acid (pH 6.2); gradual, smooth boundary.

B22tg—31 to 42 inches, dark grayish-brown (2.5Y 4/2) heavy silty clay loam; faces of peds dark gray (10YR 4/1 to 5Y 4/1), grayish brown (2.5Y 5/2) when dry; common, fine, faint, light olive-brown (2.5Y 5/4) mottles; weak, medium, prismatic structure, breaking to weak, very fine to fine, subangular blocky structure; firm; few, very dark gray coats on prism faces; few, fine, dark oxide concretions; thin, discontinuous clay films; few roots; slightly acid (pH 6.5); gradual, smooth boundary.

B3tg—42 to 50 inches, dark-gray (10YR 4/1 to 5Y 4/1) medium silty clay loam; many, medium, faint, dark grayish-brown (2.5Y 4/2) and few, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, angular blocky structure, grading to massive; firm; few tubular pores in peds; few, fine, dark oxide concretions; thin, discontinuous clay films on ped faces and in a few pores; few roots; slightly acid (pH 6.4).

The surface layer ranges from 18 to 24 inches in thickness. It is generally friable but ranges to firm, and it tends toward cloddiness if cultivated when wet. The subsoil ranges from olive gray to very dark gray, and mottling ranges from dark grayish brown to yellowish brown and olive brown. The subsoil ranges from heavy silty clay loam to light silty clay in texture and from 20 to 36 inches in thickness.

The Bremer soils in this county have a gray mottled subsoil and are more poorly drained than the Nevin and Wiota soils, which are in similar positions. They are less subject to flooding than the Colo, Wabash, and Zook soils on first bottoms. Bremer soils are not as fine textured as the Zook or Wabash soils, but they are finer textured than the Colo soils.

Bremer silty clay loam (0 to 2 percent slopes) (Br).—This soil is on all the wider stream bottoms along the Middle, North, and Grand Rivers.

Included with this soil in mapping were small areas of the Nevin, Colo, and Wabash soils.

This Bremer soil is used mainly for row crops. It is in large areas, but most of them are managed with other soils on first and second bottoms. In times of flooding and heavy rains, this soil dries out slowly, and water stands for a time in low spots. If cultivated when too wet, the surface layer becomes cloddy and remains in poor tilth for long periods.

Both surface and internal drainage are poor, and artificial drainage is necessary for good growth of crops or pasture. Tile drains work well if suitable outlets are available. In undrained pasture areas, grasses and weeds tolerant of excess water hinder the growth of more desirable grasses or legumes. (Capability unit IIw–1; woodland suitability group 11)

Caleb Series

The Caleb series consists of deep, moderately dark colored soils that formed in alluvium derived from glacial till. These soils are on side slopes of high upland benches, where slopes are 9 to 18 percent. They are moderately well drained and are in small areas near all the major streams and larger tributaries. The largest areas of Caleb soils are along the Grand River and its west branch in the southwestern part of the county. They occur in association with loess soils on benches and the Mystic soils. The native vegetation was grass and trees.

In a representative profile, the surface layer is very dark gray loam about 8 inches thick. Below this is a loam subsurface layer about 7 inches thick. It is dark grayish brown when moist and is light brownish gray when dry. The subsoil is mainly friable clay loam and sandy clay loam and is about 32 inches thick. The upper 12 inches is brown clay loam, and the lower part is yellowish-brown, friable sandy clay loam and sandy loam. It becomes more sandy with depth and is mottled with strong brown at a depth of about 40 inches. The substratum is very friable sandy loam. It is mixed yellowish brown and pale brown mottled with light brownish gray.

The Caleb soils have moderate available water capacity. Permeability is moderate in most places and moderately slow in a few places. The soils are medium to low in organic-matter content and are medium acid in the surface layer unless limed. They are low in available nitrogen, phosphorus, and potassium. These soils have a deep, favorable root zone.

Caleb soils are used for row crops, but runoff is rapid and the hazard of erosion is serious. These soils occur in small areas and are commonly managed and farmed with adjacent soils.

Representative profile of Caleb loam, 9 to 14 percent slopes, moderately eroded, 300 feet west and 1,960 feet south of the northeast corner of sec. 32, T. 74 N., R. 29 W., in a pasture on a southeast-facing slope of 10 percent:

A1—0 to 8 inches, very dark gray (10YR 3/1) loam; weak, very fine, granular structure; friable; neutral (pH 6.7); clear, smooth boundary.

A2—8 to 15 inches, very dark grayish-brown and dark grayish-brown (10YR 3/2 and 4/2) loam; discontinuous, grainy ped coatings, light brownish gray (10YR 6/2) when dry; common pores; weak, coarse, platy structure, breaking to weak, fine, subangular blocky structure; friable; medium acid (pH 6.0); gradual, smooth boundary.

B1—15 to 21 inches, brown (10YR 4/3) clay loam; dark grayish-brown (10YR 4/2) grainy coating on some peds; moderate, very fine, angular and subangular blocky structure; friable; grainy ped coatings, light brownish gray (10YR 6/2) when dry; few pores; strongly acid (pH 5.4); gradual, smooth boundary.

B21t—21 to 27 inches, brown (10YR 4/3) clay loam; weak, fine, subangular blocky structure; friable; thin, continuous clay films; few, clean sand grains on ped faces; few pores; strongly acid (pH 5.2); clear, smooth boundary.

B22t—27 to 38 inches, yellowish-brown (10YR 5/4) sandy clay loam; faces of peds dark yellowish brown (10YR 4/4); weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; friable; thin, discontinuous clay films; few, clean sand grains on ped surfaces; few pores; very strongly acid (pH 4.8); clear, smooth boundary.

B3t—38 to 47 inches, yellowish-brown (10YR 5/4) sandy loam; common, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, coarse, prismatic structure; friable; thin, discontinuous clay films on prism faces; few, clean sand grains on prism faces; few pores; very strongly acid (pH 4.6); clear, smooth boundary.

C—47 to 57 inches, mixed yellowish-brown and pale-brown (10YR 5/6 and 6/3) light sandy loam; common, fine, distinct, light brownish-gray (2.5Y 6/2) mottles; massive; very friable; material somewhat stratified; very strongly acid (pH 4.7).

The light clay loam surface layer ranges from dark grayish brown to nearly black in color and from 3 to 10 inches in thickness. The subsurface layer is light clay loam that ranges from 3 to 10 inches in thickness. The subsoil ranges from clay loam to sandy loam. Colors are typically brown to yellowish brown, but there is a wide range in amount of strong-brown mottling, and in some places a few gray mottles are in the lower part of the subsoil. The subsoil ranges to 48 inches or more in thickness. The substratum ranges from sandy loam to fine sand and has a wide range in color and mottling. A few areas on very high bench positions are underlain by limestone.

The Caleb soils differ from the Mystic soils in having a thinner, more friable, less clayey subsoil. The surface and subsurface layers of Caleb soils are similar to the Gara soils, but the Gara soils formed in glacial till in place. Caleb soils contain fewer pebbles, have a more permeable, less firm subsoil, and contain more sand in the substratum than the Gara soils.

Caleb loam, 9 to 14 percent slopes, moderately eroded (CbD2).—This soil is on side slopes of high benches near major streams and tributaries in the county. It is mainly along the north sides of streams near the ends of long sloping ridges. This soil normally is downslope from Ladoga soils on benches. Some areas are adjacent to and downslope from the Mystic soils, and extend to the bottom lands. Areas of this soil are irregular in size and shape. They generally are on short side slopes near stream bottoms and are long and narrow.

This soil has the profile described as representative for the series. In some places the surface layer is very dark grayish brown and is 3 to 7 inches thick. In some areas plowing has mixed the surface and subsurface layers and the plow layer is gray or grayish brown when dry.

Included with this soil in mapping were small areas of adjacent soils and some areas that are more sandy than is typical. If the sandy spots are significant to management, they are indicated on the soil map by the symbol for sand spots. Also included were a few areas having slopes of 5 to 9 percent and some severely eroded areas that are shown on the soil map by the symbol for severely eroded spots.

This soil is moderately suited to row crops, but runoff is rapid and the loamy surface layer erodes readily if vegetation is sparse. The soil contains short waterways that are easily gullied. It has no limitations for pasture except that small gullies may form in overgrazed spots. Where practical, individual areas of this soil are managed with other soils. (Capability unit IIIe-1; woodland suitability group 7)

Caleb-Mystic loams, 9 to 14 percent slopes, moderately eroded (CeD2).—These soils are on short side slopes of benches near all the major streams and tributaries. They are downslope from the Givin and Ladoga soils on benches and upslope from the Colo, Kennebec, and Zook soils of the bottom lands. On a few narrow, rounded benches they are on the entire benchtop and side slope. They are upslope from the Ely or Olmitz soils on foot slopes.

A typical area consists of somewhat poorly drained Mystic soils on the upper half of side slopes and the moderately well drained Caleb soils on the lower half. Caleb soils make up about 50 percent of this mapping unit, and Mystic soils most of the remaining 50 percent. The profiles of these soils are similar to those described as representative for their respective series. The surface layer averages 3 to 7 inches in thickness, ranges from loam to light clay loam, and is very dark grayish brown.

Included with these soils in mapping were small upslope areas of Ladoga or Givin soils. Also included were areas of slightly eroded and severely eroded soils. Small, sandy areas within areas of the Caleb soil are indicated by the spot symbol for sand, and included severely eroded areas are shown by a symbol for severe erosion. Also included were a few areas of a soil having slopes of 5 to 9 percent.

Because the soils of this complex are in small areas, they are generally managed with other soils for crop or pasture. There are a few waterways that are easily gullied. The organic-matter content generally is low, and soil tilth is poor in places.

These soils are poorly suited to row crops even if erosion is controlled and gullies are filled and seeded. (Capability unit IVe-2; woodland suitability group 7)

Caleb-Mystic loams, 14 to 18 percent slopes, moderately eroded (CeE2).—These soils occur on side slopes of high benches. They are downslope from Ladoga soils on benches and are upslope and adjacent to first and second bottoms near major streams. Slopes are longer and benches are normally higher than in the strongly sloping Caleb-Mystic loams.

Caleb soils make up about 60 percent of the mapping unit, and Mystic soils most of the remaining 40 percent. The profiles of these soils are similar to those described as representative for their respective series. Their surface layer ranges from 3 to 7 inches in thickness. The soils in this unit are slightly lighter colored in the surface layer near the timbered areas along Middle River than they are in the southern part of the county.

Included with these soils in mapping were small areas that are slightly eroded or severely eroded. Severely eroded areas are indicated on the soil map by a symbol for severely eroded spots. Also included were a few areas that are strongly sloping and steeply sloping.

Soils in this complex are not extensive but are locally important. They are not suited to row crops, but some small areas are managed with more suitable soils as cropland.

Runoff is rapid to very rapid because of the moderately steep slopes. Gullies form easily in side drains, and the hazard of erosion is serious. Fertility is low. If erosion is controlled, gullies are stabilized. By applying adequate fertilizers and lime, good pasture and legumes can be grown. (Capability unit VIe-2; woodland suitability group 7)

Clanton Series

The Clanton series consists of deep, moderately dark soils that have a clayey subsoil. These soils of the uplands formed in material weathered from shale. They are on low ridges where slopes are 9 to 18 percent and on side slopes where slopes are 14 to 25 percent. They are downslope from limestone outcrops or ledges and from the Nordness soils. In some places where limestone strata are absent, Clanton soils are downslope from the Gara soils. They are most common in the central part of the county along the North and Middle Rivers and along Clanton Creek near the town of Peru. The native vegetation is trees and grasses. Natural drainage is difficult to determine, but these soils are considered to be moderately well drained.

In a representative profile, the surface layer is dark reddish-brown silt loam about 8 inches thick. The subsurface layer is silt loam about 3 inches thick. It is reddish brown and friable. The reddish-brown, very firm subsoil is silty clay in the upper part and silty clay loam in the lower part. It extends to a depth of about 38 inches. The substratum is firm, reddish-brown shaly silty clay loam that has light yellowish-brown mottles.

The Clanton soils have low available water capacity, and their permeability is very slow. These soils resist saturation, because it is difficult for water and plant roots to penetrate the shale. They tend to be droughty, and plants are shallow rooted. They are slightly acid to medium acid in the surface layer unless limed, and they are low in organic-matter content. They are very low in available nitrogen and phosphorus and low in available potassium. If vegetation is removed or becomes thin, the soils will erode severely. Runoff is rapid because of the very slow permeability of the subsoil and substratum. Gullies form easily if timber is cleared.

Clanton soils are not suited to row crops. Where the surface layer is thickest and runoff is controlled, these soils provide some pasture. In most areas they are better suited to woodland and wildlife habitat than to other uses. Large areas can be managed separately, but small areas are managed with the adjacent more dominant soils.

Representative profile of Clanton silt loam, 14 to 25 percent slopes, moderately eroded, 1,900 feet south and 1,380 feet west of the northeast corner of sec. 6, T. 74 N., R. 26 W., in a timber pasture on a slope of 15 percent:

A1—0 to 8 inches, dark reddish-brown (5YR 3/2) silt loam; reddish gray (5YR 5/2) when dry; weak, fine, platy structure and weak, fine, granular structure; friable; few reddish-brown (5YR 4/3) peds in lower part; neutral (pH 6.8); clear, smooth boundary.

A2—8 to 11 inches, reddish-brown (5YR 4/3) heavy silt loam; light reddish brown (5YR 6/3) when dry; weak, medium, platy structure, breaking to weak, medium, subangular blocky structure; friable; common, fine, tubular pores; medium acid (pH 5.8); gradual, smooth boundary.

IIB21t—11 to 17 inches, reddish-brown (5YR 4/3) silty clay; reddish brown (5YR 5/3) when dry; moderate, fine and very fine, subangular blocky structure; very firm; thin, discontinuous clay films; common, fine, tubular pores; medium acid (pH 5.7); gradual, smooth boundary.

IIB22t—17 to 29 inches, reddish-brown (5YR 4/3) silty clay; reddish brown (5YR 5/3) when dry; moderate, fine, angular blocky structure; very firm; thin, continuous clay films; common, fine, tubular pores; very strongly acid (pH 4.8); gradual, smooth boundary.

IIB3t—29 to 38 inches, reddish-brown (5YR 4/3) heavy silty clay loam; reddish brown (5YR 5/3) when dry; weak, coarse, platy structure, breaking to weak, medium, subangular blocky structure; structure partly due to the shale parent material; very firm; thin, discontinuous clay films; slightly acid (pH 6.5); gradual, smooth boundary.

IIC—38 to 48 inches, reddish-brown (5YR 4/3) shale of silty clay loam texture; common, fine, prominent, light yellowish-brown (2.5Y 6/4) mottles; platy structure due to the shale parent material; firm; neutral (pH 7.0).

The surface layer ranges from 6 to 10 inches in thickness. In some places where the surface layer is thin, part of the reddish-brown subsurface layer is mixed with it. In some uneroded areas the surface layer is very dark brown. The subsoil ranges from 24 to 48 inches in thickness and from reddish brown to reddish gray and dark red in color. Some areas appear to have a purplish-red cast. The underlying shale is mainly reddish brown but is lighter in color than the subsoil and contains strata of gray and yellowish-brown shale. There is a wide range in thickness of various shale strata. In some places, at a depth of 5 or 6 feet, gray and brown are the dominant colors.

The subsoil of the Clanton soils is reddish-brown, whereas that of the Gosport soils is gray to brown.

Clanton silt loam, 9 to 14 percent slopes, moderately eroded (ClD2).—This soil generally occupies talus slopes below limestone ledges. In places where limestone is not present, the soil is downslope from the Gara soils.

Included with this soil in mapping were small areas where the subsurface layer is exposed and small areas of the Gosport soils. Also included were some severely eroded areas that are indicated on the soil map by the symbol for severely eroded spots.

Permeability is very slow and runoff is rapid, especially if this soil is in pasture. The surface layer takes in water fairly well but it is too thin to slow runoff. Roots do not penetrate the subsoil readily.

This Clanton soil is better suited to woodland or wildlife habitat than to most other uses, but some areas are cleared and are in pasture. Small areas are managed with adjacent soils. Because of the clayey subsoil, this soil is droughty and erodible. (Capability unit VIe–3; woodland suitability group 9)

Clanton silt loam, 14 to 25 percent slopes, moderately eroded (ClF2).—This soil occupies talus slopes below limestone ledges. It is in small areas along the North and Middle Rivers, their tributaries, and Clanton Creek. In some places less sloping Clanton soils are upslope.

Included with this soil in mapping were severely eroded areas where the subsurface layer or subsoil is exposed. Also included were small areas of Nordness, Gara, and Gosport soils.

This Clanton soil is suited to woodland or wildlife habitat, but it is generally managed with adjacent areas. The erosion hazard is very severe if the soil is cleared of trees and shrubs. Droughtiness, slow permeability, and poor root development limit the response to treatment. (Capability unit VIIe–2; woodland suitability group 9)

Clanton-Gosport silt loams, 9 to 14 percent slopes, moderately eroded (CmD2).—These soils are in such intricate patterns that they were not separated on the soil map. Clanton soils make up about 60 percent of the complex, and Gosport soils nearly 40 percent. These soils are throughout the limestone and shale areas of the county. They are generally adjacent to and between the Gara or Lindley soils upslope and steeper shale-derived soils downslope. In some areas these soils are on talus slopes below rock outcrops and are adjacent to alluvial soils on stream bottoms.

The Clanton and Gosport soils in this mapping unit have profiles similar to those described under their respective series.

Included with these soils in mapping were small areas of Gara, Lindley, and Nordness soils. Significant areas of Gara or Lindley soils are indicated on the soil map by a symbol for glacial till spots. In some areas the underlying shale is mixed with and contains fragments of limestone or sandstone. In these areas the surface layer contains more material of sand size than is typical. Such an area is in the eastern part of the county near the town of St. Charles.

Nearly all areas of these soils are in pasture or wooded pasture. A few very small areas are in crops and are managed with adjacent soils. The tilth is generally good, and these soils are more accessible to machinery than steeper soils derived from shale. Permeability is very slow. These soils are droughty, subject to erosion, and low in fertility, but if erosion is controlled and rainfall is sufficient, the soils produce some pasture. (Capability unit VIe–3; woodland suitability group 9)

Clanton-Gosport silt loams, 14 to 18 percent slopes, moderately eroded (CmE2).—The soils in this mapping unit are moderately steep and are on irregular side slopes below areas of the Gara or Lindley soils or less sloping soils derived from shale. The Clanton and Gosport soils are so intermingled that they were not separated on the soil map. Clanton soils make up about 55 percent of the mapping unit, and Gosport soils nearly 45 percent.

These soils have profiles similar to those described as representative for their respective series, but they are moderately eroded and in many places the surface layer is thinner.

Included with these soils in mapping were small areas of Gara and Lindley soils. Also included were some severely eroded areas where the surface layer and subsoil have been mostly or entirely eroded away.

These soils are not suited to row crops. Their use is severely limited by the hazard of erosion and by droughtiness and slope. Most areas are in wooded pasture, but some are in timber or brush. Pasture is normally poor, because fertility is low to very low. Growth of trees is slow, but use of these soils for woodland and wildlife habitat helps to control erosion. (Capability unit VIIe–2; woodland suitability group 9)

Clanton-Gosport silt loams, 18 to 25 percent slopes, moderately eroded (CmF2).—These soils are the most extensive of the Clanton-Gosport silt loams. The Clanton soils make up about 50 percent of the mapping unit, and the Gosport soils nearly 45 percent. Each has a profile similar to the one described as representative for its respective series. The soils are downslope from the Gara and Lindley soils.

Included in mapping were areas of Nordness soils and areas of limestone outcrops.

Soils of this mapping unit are suited to woodland and wildlife habitat. They are not suited to row crops. Most of the acreage is in pasture or woodland. The hazard of erosion and the limitation of droughtiness are very severe. (Capability unit VIIe–2; woodland suitability group 9)

Clanton-Gosport silt loams, 25 to 40 percent slopes, moderately eroded (CmG2).—These very steep soils are on side slopes that are downslope from the Gara and Lindley soils, and they extend to stream bottoms. Clanton soils make up 55 percent of the mapping unit, and Gosport soils nearly 45 percent.

The profiles of these soils are similar to those described as representative for their respective series, but the texture of the surface layer differs within short distances. It is commonly silty clay loam or silt loam. There are many stabilized or partially stabilized gullies.

Included with these soils in mapping were large areas of steep and very steep Lindley and Gara soils. Also included were many small areas of the Nordness soils. Limestone outcrops are common.

These soils are not used for crops, and they produce low-quality pasture. Growth of trees and shrubs is slow. If trees and shrubs are removed, runoff is excessive and the hazard of erosion is very serious. Slopes are too steep for the use of farm equipment in renovating existing pastures. (Capability unit VIIe-2; woodland suitability group 9)

Clarinda Series

The Clarinda series consists of deep, dark colored and moderately dark colored, very poorly drained soils that formed in highly weathered, very fine textured glacial till on uplands. The native vegetation was water-tolerant prairie grasses. These soils are on short side slopes or around the heads of drainageways where slopes are 5 to 9 percent. They are downslope from the Clearfield and Sharpsburg soils and upslope from the Lamoni and Shelby soils. Individual areas are in every part of the county. Areas are small, and those less than 2 acres in size are indicated on the soil map by the symbol for gray clay spots.

In a representative profile, the surface layer is black and very dark gray silty clay loam about 16 inches thick. It has a few dark grayish-brown mottles in the lower part. The subsoil extends to a depth of about 52 inches. The upper 7 inches is dark-gray to dark grayish-brown, very firm silty clay. This is underlain by gray silty clay or clay that has yellowish-brown and strong-brown mottles. It is very firm when moist and sticky or plastic when wet. This layer is sticky, gray clay commonly known as gumbotil. The gumbotil is underlain by a mixed gray and yellowish-brown, firm clay loam glacial till. This layer contains more sand and has olive-gray and brown mottles. The detailed profile described as representative for the series is not described to a depth great enough to show this glacial till.

The Clarinda soils are so fine textured that the water they hold cannot readily be used by many crops. Available water capacity is moderate. Permeability is very slow, and these soils dry out very slowly. These soils are medium to high in organic-matter content. Most areas are slightly acid to medium acid in the surface layer unless limed. They are low in available nitrogen and phophorus and low to medium in available potassium. Roots are abundant in the surface layer, but they have difficulty in penetrating the fine textured subsoil. Infiltration of surface water is also very slow, and therefore runoff is rapid. The hazard of erosion is severe if vegetation is sparse.

The major concern of management is wetness because of seepage at the contact of Clarinda soils and the more permeable soils upslope. Clarinda soils are managed as pasture where possible, but some areas are managed with more suitable adjacent soils. If the wetness cannot be corrected, plants for wildlife habitat are an alternative.

Representative profile of Clarinda silty clay loam, 5 to 9 percent slopes, 140 feet east and 50 feet north of the southwest corner of sec. 14, T. 77 N., R. 29 W., in a pasture on a slope of 7 percent:

A1—0 to 11 inches, black (10YR 2/1) light silty clay loam; dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure, breaking to weak, fine, granular structure; friable; neutral (pH 6.5); gradual, smooth boundary.

A3—11 to 16 inches, very dark gray (10YR 3/1) silty clay loam; many, fine, faint, dark grayish-brown (10YR 4/2) mottles; weak, very fine, subangular blocky structure; firm; medium acid (pH 6.0); gradual, smooth boundary.

IIB21tg—16 to 23 inches, dark-gray to dark grayish-brown (N 4/0 to 2.5Y 4/2) silty clay; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; very firm; some very dark gray (10YR 3/1) coatings carrying down on prism faces; thin, continuous clay films; colors partly inherited from paleo B of Yarmouth-Sangamon paleosol; medium acid (pH 5.8); gradual, smooth boundary.

IIB22tg—23 to 36 inches, gray (5Y 5/1) heavy silty clay; few, fine, distinct, yellowish-brown (10YR 5/4) mottles increasing with depth; moderate, medium, prismatic structure, breaking to moderate, fine, angular blocky structure; very firm; thick, continuous clay films; few, fine, tubular pores; few, medium sand grains; few, very dark gray (10YR 3/1) areas in old root channels and voids; color partly inherited from paleo B of Yarmouth-Sangamon paleosol; slightly acid (pH 6/4); gradual, smooth boundary.

IIB23tg—36 to 52 inches, gray (5Y 5/1) clay; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; few, coarse, prominent, strong-brown (7.5YR 5/8) mottles in lower part of horizon; moderate, medium to fine, prismatic structure, breaking to weak, medium and fine, angular blocky structure; very firm; thin, continuous clay films; common, medium to coarse sand grains; few very dark gray (10YR 3/1) krotovinas; color partly inherited from paleo B of Yarmouth-Sangamon paleosol; neutral (pH 6.6).

The surface layer is dark-gray to black silty clay loam ranging from 7 to 18 inches in thickness. The subsoil ranges from 2½ to 6 feet in thickness. Gray or olive gray is the dominant color, but there is a wide range in the amount and size of yellowish-brown and strong-brown mottles. Reddish mottles occur in some areas. The subsoil is silty clay or clay. The gumbotil subsoil is underlain by firm clay loam glacial till. This layer contains some stones and pebbles. It is commonly light gray highly mottled with brown, olive gray, and red. It ranges from gray to yellowish brown with a wide range in mottling.

Clarinda soils have a more silty surface layer than the Lamoni soils. They also differ from the Lamoni soils in having a thick, compact, highly weathered, gray gumbotil subsoil, and they have a lower sand content in the subsoil, are less sloping, and are grayer in the subsoil.

Clarinda silty clay loam, 5 to 9 percent slopes (CnC).—This moderately sloping soil is in coves at the heads of waterways and extends laterally for short distances on side slopes. It is downslope from Clearfield, Nira, and Sharpsburg soils, and it is upslope from the Shelby soils. It is in small areas.

Permeability in the surface layer is moderately slow, but it is very slow in the subsoil, and this prevents water from draining through the soil. This soil holds water and is seepy during months of normal rainfall, but it becomes very hard during dry periods.

Included with this soil in mapping were very small areas of Clearfield and Lamoni soils.

Most of this soil is in pasture. When saturated it dries out very slowly, and weeds and grasses tolerant to excess wetness are evident. It is poorly suited to row crops, but a few small areas are plowed and managed with more permeable soils adjacent to them. Runoff is rapid, and there is a serious hazard of erosion if this soil is plowed.

The major concern in managing this soil is the wet, seepy condition caused by drainage water moving laterally over the gumbotil from the more permeable soils upslope. Tile drains will not function in the Clarinda soil itself, but interceptor tile lines in the permeable soils above are beneficial in removing excess water. (Capability unit IVw–1; woodland suitability group 9)

Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded (CnC2).—This moderately sloping soil is in coves near the heads of waterways. It extends laterally in thin bands along side slopes and is downslope from the Clearfield, Nira, and Sharpsburg soils and is upslope from the Shelby or Lamoni soils. It is in small areas.

The profile of this soil is similar to that described as representative for the series, but it has a very dark gray surface layer that averages about 7 inches in thickness. Small areas of gumbotil subsoil are exposed in places.

Included with this soil in mapping were small eroded areas of the Clearfield and Lamoni soils. Also included were severely eroded areas of Clarinda soils that are indicated on the soil map by the symbol for severely eroded spots.

This soil is poorly suited to row crops, but in places small areas are managed with adjacent soils and used for crops. Some areas are left in grass vegetation within cultivated fields.

Permeability is very slow, and the soil becomes saturated during normal rainfall. It dries out very slowly, but becomes very hard and cracks during long dry periods.

This soil is low in plant nutrients and has poor tilth. Runoff is rapid even if the soil is in grass or weedy vegetation. The major concern in managing this soil is the very wet, seepy condition caused by water moving laterally across the gumbotil layer from the more friable, permeable soils upslope. Interceptor tile drainage in these permeable soils is beneficial to this Clarinda soil. (Capability unit IVw–1; woodland suitability group 9)

Clearfield Series

The Clearfield series consists of deep, dark-colored, poorly drained, seepy soils of the uplands that formed in thin loess under a native vegetation of water-tolerant prairie grasses. These soils have slopes of 5 to 9 percent. They are at the heads of draws or in thin bands on the upper side slopes. They are in small areas in all parts of the county, downslope from the gently sloping high divides. They are downslope from the Macksburg and Sharpsburg soils and upslope from the Clarinda soils.

In a representative profile, the surface layer is silty clay loam about 17 inches thick. The upper 12 inches of this layer is typically black, and the lower 5 inches is very dark gray. The subsoil is gray, dark grayish-brown, and dark-gray silty clay loam about 27 inches thick. It is friable and has brown and yellowish-brown mottles that increase with depth. The substratum, at a depth of about 44 inches, is a dark-gray, very firm, very slowly permeable glacial till layer, commonly referred to as gumbotil. It is a silty clay in texture.

The Clearfield soils have high available water capacity and moderately slow permeability. They are normally wet and seepy in both the surface layer and the subsoil because drainage water from the more permeable loess moves laterally over the compact, very slowly permeable, underlying clayey layer. Wetness restricts root growth in most areas. The surface layer is slightly acid unless limed and is high in organic-matter content. These soils are low to medium in available nitrogen and potassium, and they are low in available phosphorus.

If the wetness is corrected, these soils are suited to row crops, but they are subject to erosion. Where the soils are in row crops, erosion control practices are needed to prevent excessive soil loss.

Representative profile of Clearfield silty clay loam, 5 to 9 percent slopes, 200 feet west and 250 feet north of the southeast corner of the SW¼NE¼ sec. 25, T. 75 N., R. 28 W., in a cultivated field on a slope of 7 percent:

Ap—0 to 7 inches, black (10YR 2/1) medium silty clay loam; cloddy, breaking to weak, fine, granular structure; friable; plentiful roots; neutral (pH 6.8); abrupt, smooth boundary.

A1—7 to 12 inches, black (10YR 2/1) medium to heavy silty clay loam; moderate, medium and fine, granular structure; friable; neutral (pH 6.8); gradual, smooth boundary.

A3—12 to 17 inches, very dark gray (10YR 3/1) medium to heavy silty clay loam; few, fine, faint, yellowish-brown (10YR 5/4) mottles at a depth of 15 inches; moderate, very fine, subangular blocky structure; friable; neutral (pH 6.6); gradual, smooth boundary.

B21tg—17 to 23 inches, dark-gray (10YR 4/1) medium silty clay loam; many, fine and medium, distinct, olive-brown (2.5Y 4/4) mottles; weak, medium, subangular blocky structure, breaking to moderate, fine, subangular blocky structure; friable; black (10YR 2/1) organic coating in root channels and pores; thin, discontinuous, very dark gray clay films; slightly acid (pH 6.4); gradual, smooth boundary.

B22tg—23 to 31 inches, dark grayish-brown (2.5Y 4/2) medium silty clay loam; many, fine, distinct, yellowish-brown (10YR 5/4 and 5/6) mottles; few, fine, distinct, brown (7.5YR 4/4) mottles and few, fine, distinct, yellowish-brown (10YR 5/8) mottles; moderate, medium, subangular blocky structure; friable; thin, discontinuous clay films; common, fine and medium, black oxides; slightly acid (pH 6.4); gradual, smooth boundary.

B23tg—31 to 39 inches, gray (2.5Y 5/1) light silty clay loam; many, medium, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles and a few, fine, prominent, brown (7.5YR 4/4) mottles; weak, medium, prismatic structure, breaking to moderate, medium, subangular blocky structure; friable; thin, discontinuous, dark-gray clay films on prism faces; few organic clay coatings in pores and fine root channels; neutral (pH 6.6); gradual, smooth boundary.

B3g—39 to 44 inches, gray (N 5/0) light silty clay loam; many, medium and coarse, prominent, yellowish-brown (10YR 5/6 and 5/8) mottles and few, fine, prominent, brown (7.5YR 4/4 and 4/6) mottles; weak, medium, prismatic structure, breaking to weak, coarse, subangular blocky structure; friable; neutral (pH 6.6); abrupt, smooth boundary.

IIBb—44 to 52 inches, dark-gray (10YR 4/1) silty clay; very firm; Yarmouth-Sangamon paleosol to a depth of many feet; neutral (pH 6.8).

Where cultivated, the surface layer is very dark gray in some profiles. In uneroded areas the surface layer is typically black and ranges from 10 to 20 inches in thickness. The subsoil ranges from gray to dark grayish brown or olive gray in color and from 2 to 4 feet in thickness. The depth to clayey gumbotil ranges from 3 to 5 feet. In areas where the loess is thickest over the underlying clayey layer, the subsoil is somewhat better drained and has more mixing of brown color and mottles.

The Clearfield soils are grayer in the subsoil and more poorly drained than the Nira and Sharpsburg soils. They have clayey gumbotil at a depth of 3 to 5 feet, have steeper slopes, and are more poorly drained than the Macksburg soils.

Clearfield silty clay loam, 5 to 9 percent slopes (CoC).—This soil is near the heads of upland drainageways and is downslope from the gently sloping Macksburg and Sharpsburg soils. It is adjacent to and upslope from the Clarinda soils. In places in the southeastern part of the county, this soil is adjacent to areas of Nira soils. It is commonly in coves around heads of waterways, but some areas extend into narrow areas on side slopes. On some side slopes this soil is adjacent to the moderately sloping Nira and Sharpsburg soils. This soil has the profile described as representative for the series.

Included with this soil in mapping were very small areas of Sharpsburg or Macksburg soils and, at the lower border, areas of Clarinda soils. Significant spots of Clarinda soils are indicated on the map by the symbol for clay spots.

This soil is moderately suited to row crops if drainage is installed and erosion is controlled. Over half the acreage of this soil is in crops, but many undrained areas remain in pasture. Individual areas are small and are managed with the adjacent Macksburg and Sharpsburg soils.

The major concerns in managing this soil are wetness and seepiness. Moderate slopes and runoff make this soil subject to erosion. It commonly contains waterways that are very wet. These tend to gully easily near the junction with the Clarinda soils and other soils that are downslope. (Capability unit IIIw-1; woodland suitability group 11)

Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded (CoC2).—This soil is in coves around heads of upland drainageways that break abruptly from the broad upland divides. It is downslope from the Macksburg and Sharpsburg soils and upslope from the Clarinda soils. It is normally adjacent to the moderately eroded Nira and Sharpsburg soils, which are on the rounded side slopes between the drainageways. It is in small areas.

This soil is poorly drained, and erosion has removed part of the original surface layer. Consequently, this layer is thinner than that in the profile described as representative for the series. Only 3 to 7 inches of the original surface layer remains. Gray and grayish-brown colors are mixed in the plow layer.

Included with this soil in mapping were small, less eroded areas and very small, upslope areas of better drained Macksburg and Sharpsburg soils. Also included, near the lower boundary of areas of this soil, were small spots of Clarinda soils. If these areas are significant, they are indicated on the soil map by the symbol for clay spots.

This soil is moderately suited to row crops, and most areas are in crops. Runoff is more rapid because part of the absorptive surface layer has been removed by erosion.

The subsoil is wet and seepy unless tiled. In some areas the surface layer is difficult to work because plowing has mixed subsoil material into it. Plowing this layer when wet tends to make it cloddy. Individual areas of this soil are small in size, and most of them are managed with the adjacent Sharpsburg soils. If the wetness is corrected and erosion is controlled, this soil is moderately suited to row crops. (Capability unit IIIw-1; woodland suitability group 11)

Clinton Series

The Clinton series consists of deep, light-colored, moderately well drained soils of the uplands that formed in loess in the central and eastern parts of the county. These soils are on narrow, rounded ridgetops where slopes are 2 to 9 percent, and on side slopes where slopes are 5 to 14 percent. They are also on some high, undulating, and gently sloping benches near the major streams.

The Clinton soils are adjacent to the Ladoga soils and are upslope from the strongly sloping to steep Gara, Keswick, and Lindley soils. Many areas of the Clinton soils are densely wooded. The native vegetation was trees.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 4 inches thick. The subsurface layer is brown silt loam about 5 inches thick. It is very pale brown when dry. The subsoil, to a depth of 52 inches, is dark yellowish-brown and yellowish-brown slity clay loam and light silty clay. In the lower part of the subsoil there are some brown and light brownish-gray mottles. The substratum is friable, yellowish-brown light silty clay loam. It is mottled with strong brown and olive gray. The substratum is not shown in the detailed description of the representative profile.

The Clinton soils formed in loess that is underlain by weathered glacial material. The loess ranges from about 12 feet thick on ridgetops to about 4 feet thick on some side slopes. In places where the loess is thinnest, there are narrow bands of soils that are somewhat poorly drained.

Clinton soils have high available water capacity and moderately slow permeability. They are medium acid to strongly acid in the surface layer unless limed. They are low to very low in available nitrogen, very low to medium in available phosphorus, and low to medium in available potassium. These soils are moderately low to very low in organic-matter content. They have a deep, favorable root zone.

Individual areas of these soils are commonly long and narrow, and some are large enough to be managed separately. These are in row crops, but many small areas on narrow ridges are in pasture or timber and are managed with the steeper Gara and Lindley soils. The Gara and Lindley soils are less suited to crops.

The Clinton soils are subject to erosion if cultivated, and erosion control practices are needed.

Representative profile of Clinton silt loam, 2 to 5 percent slopes, 2,710 feet north and 1,660 feet east of the southwest corner of sec. 19, T. 75 N., R. 26 W., on a timbered ridgetop on a convex slope of 3 percent:

O1—½ inch to 0, black (10YR 2/1) partially decomposed roots and leaves; silt loam; weak, fine, granular structure; very friable; abrupt, smooth boundary.

A1—0 to 4 inches, very dark grayish-brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; medium acid (pH 6.0); clear, smooth boundary.

A2—4 to 9 inches, brown (10YR 4/3) silt loam; very pale brown (10YR 7/3) when dry; light-gray (10YR 7/2) grainy coatings on ped faces; weak, fine, platy structure, breaking to weak, fine, granular structure; friable; medium acid (pH 5.6); abrupt, smooth boundary.

B1—9 to 16 inches, dark yellowish-brown (10YR 4/4) silty clay loam; light yellowish brown (10YR 6/4) when dry; light-gray (10YR 7/2) silt coatings on ped faces; weak to moderate, fine, subangular blocky structure; friable; strongly acid (pH 5.2); clear, smooth boundary.

B21t—16 to 25 inches, dark yellowish-brown (10YR 4/4) silty clay; light yellowish brown (10YR 6/4) when dry; faint, pale-brown (10YR 6/3) coatings on ped faces; moderate, fine, angular and subangular blocky structure; firm; thick, continuous clay films on ped faces; few, fine, very dark gray (10YR 3/1) oxide stains; few roots; strongly acid (pH 5.2); gradual, smooth boundary.

B22t—25 to 33 inches, yellowish-brown (10YR 5/4) silty clay; faces of peds dark yellowish-brown (10YR 4/4); few, fine, faint, brown (7.5YR 4/4) mottles; moderate, medium, subangular blocky structure; firm; thin, discontinuous clay films on ped faces; many, very dark gray (10YR 3/1) oxide stains; strongly acid (pH 5.2); gradual, smooth boundary.

B23t—33 to 39 inches, yellowish-brown (10YR 5/4) heavy silty clay loam; few, medium, faint, dark yellowish-brown (10YR 4/4) mottles and common, medium, distinct, light brownish-gray (10YR 6/2) mottles; weak to very weak, medium, subangular blocky structure; firm; thin, discontinuous clay films on ped faces; common, very dark gray (10YR 3/1) oxide stains; strongly acid (pH 5.2); gradual, smooth boundary.

B3t—39 to 52 inches, yellowish-brown (10YR 5/4) silty clay loam; few, fine, faint, brown (7.5YR 4/4) mottles and few, medium, faint, yellowish-brown (10YR 5/6) mottles; common, medium, distinct, pale-brown (10YR 6/3) mottles; some vertical cleavage; friable; very few, thin, discontinuous clay films; few discontinuous silt coats; common, very dark gray (10YR 3/1) oxide stains; strongly acid (pH 5.4).

The surface layer ranges from very dark grayish brown to pale brown, depending on the degree of erosion and the depth of plowing. In cultivated areas the surface layer is very light gray when dry. Its texture commonly is silt loam but ranges to light silty clay loam. Uneroded areas have a very dark gray or very dark grayish-brown silt loam surface layer that is 2 to 5 inches thick. The lighter colored subsurface layer ranges from 3 to 6 inches in thickness. These layers are mixed by plowing. The subsoil ranges from 24 to 40 inches or more in thickness and from silty clay loam to light silty clay in texture. The maximum clay content of the subsoil in the representative profile is slightly higher than is typical for the series. The amount of brown and gray mottling in the lower part of the subsoil varies widely.

The Clinton soils have a thinner surface layer and a thicker, more evident subsurface layer than the Ladoga soils. They have a thinner surface layer than the Sharpsburg soils, and they have a brown subsurface layer that the Sharpsburg soils do not have.

Clinton silt loam, 2 to 5 percent slopes (CsB).—This soil is gently sloping on slightly rounded, narrow ridgetops, where the relief generally is steeper near the major streams. Typical areas are surrounded by moderately sloping Clinton soils near the point of the ridge, and are adjacent to the Ladoga soils which are on the broader ridgetops upslope.

This soil has the profile described as representative for the series.

The combined thickness of its surface and subsurface layers is 7 to 11 inches. Its subsoil is dark yellowish-brown and yellowish-brown silty clay loam and silty clay.

Included with this soil in mapping were very small areas of more severely eroded and more sloping Clinton soils.

If erosion is controlled, this soil is well suited to row crops. It is in narrow areas, and therefore most areas are managed with adjacent soils as croplands. Some areas are in pasture. (Capability unit IIe–3; woodland suitability group 3)

Clinton silt loam, 5 to 9 percent slopes (CsC).—This soil is moderately sloping on sharply rounded ridgetops and narrow divides. These ridges extend back to broad, less sloping divides occupied by Clinton or Ladoga soils. This soil lies upslope from Lindley soils or from strongly sloping Clinton soils. Some areas are adjacent to the Keswick soils, which are on the lower points of ridges.

On most of its acreage, this soil is not cultivated and has a thin, very dark grayish-brown surface layer and a brown subsurface layer. It has a dark yellowish-brown silty clay loam to light silty clay subsoil that is moderately slow in permeability.

Included with this soil in mapping were small areas of strongly sloping and more eroded Clinton soils. Also included in the lower part of some areas mapped as this soil were very small areas of the Keswick and Lindley soils. Significant areas of Keswick and Lindley soils are indicated on the soil map by the symbol for glacial till spots.

This soil is moderately suited to row crops if erosion is controlled, but most of it is in timber or pasture. Some areas have been cleared and are managed separately from adjacent steeper side slopes.

This soil is subject to erosion if cultivated. Heads of hillside drainageways are in this soil, and gullies are readily formed. (Capability unit IIIe–2; woodland suitability group 3)

Clinton silt loam, 5 to 9 percent slopes, moderately eroded (CsC2).—This moderately sloping soil is on sharply rounded ridgetops and narrow divides in the steeper areas of the county. It is also in narrow bands downslope from gently sloping Clinton soils. These ridges and short side slopes extend back toward broader ridges occupied by Ladoga soils. This soil is upslope from Keswick and Lindley soils and from areas of strongly sloping Clinton soils.

The profile of this soil differs from the one described as representative for the series in that erosion has removed part of the surface layer, leaving 3 to 7 inches of material that is a mixture of the original surface and subsurface layers. In areas that are in pasture or that are thinly wooded, the brown and light-gray silty subsurface layer is exposed, so that the present surface layer is distinctly light colored when dry.

Included with this soil in mapping were very small areas in which erosion is slight or severe. Also included, near the lower edge of some areas mapped as this soil, were small areas of the Keswick and Lindley soils. The more significant areas of severe erosion and of glacial till are indicated on the soil map by the symbol for erosion and glacial till spots.

Most of this soil is in crops. It is moderately suited to row crops if erosion is controlled. Because runoff is medium to rapid, the soil is subject to erosion. In places, plowing has mixed some of the upper part of the subsoil and the remaining surface layer. This results in poorer tilth and a tendency to cloddiness. Heads of hillside drainageways extend into this soil and, in places, have formed small gullies. Organic-matter content is very low, and this soil is less fertile than the uneroded Clinton soils. (Capability unit IIIe–2; woodland suitability group 3)

Clinton silt loam, 9 to 14 percent slopes, moderately eroded (CsD2).—This strongly sloping soil is on side slopes below other Clinton soils, and it is upslope and adjacent to the Lindley soils. It is also in very short, irregular bands or oval-shaped areas around hillside drainageways.

This soil has a grayish-brown surface layer 3 to 7 inches thick. In plowed fields the subsurface layer is mixed with the surface layer. In places some of the upper part of the subsoil is mixed into the plow layer. The brown and grayish subsurface layer is exposed in areas that are in pasture or lightly wooded, and it is distinctly light colored when dry. Gray and brown mottles are more common in the lower part of this soil than in other Clinton soils.

Included with this soil in mapping were some small areas of slightly eroded and severely eroded Clinton soils. Severely eroded areas are shown on the soil map by the symbol for severely eroded spots. Also included were small areas of strongly sloping Lindley soils that are downslope. The more significant areas are indicated on the soil map by the symbol for glacial till spots.

This soil is moderately suited to row crops if erosion is controlled. Individual areas are small, and many of them are managed with the less sloping Clinton soils as cropland. Some are managed with less suitable soils as pasture. This soil is subject to severe erosion because it has strong slopes and rapid runoff. Waterways are present in most areas, and rapid concentration of water creates gullies. Some of these gullies cannot be crossed by farm machinery.

The surface layer is very low in organic-matter content, and in many places soil tilth is poor. Fertility is lower than in the less eroded Clinton soils. (Capability unit IIIe-2; woodland suitability group 3)

Clinton silt loam, benches, 2 to 5 percent slopes (CtB).—This soil is on slightly rounded tops of stream benches near major streams bordered by steep, heavily wooded uplands. The part farthest from the stream is adjacent to the steep Clinton, Gosport, and Lindley soils. The side slopes and escarpments adjacent to this soil nearer the streams are occupied by Caleb and Mystic soils. In a few places, these gently sloping benches extend to first bottoms occupied by Nodaway soils. In other places, this soil is upslope from low escarpments of limestone bedrock.

This soil differs from the soil having the profile described as representative for the series in that it is on stream benches and its substratum grades to coarser textured, stratified materials ranging from sand to clay loam. It commonly has fewer grayish mottles in the lower part of the subsoil because of the underlying permeable materials.

Included with this soil in mapping were small areas of fine sandy loam or fine sand blown up from the nearby bottom lands and very small areas of more poorly drained Vesser soils. Where significant, areas of sand and of steep escarpments are indicated on the soil map by spot symbols.

This soil is well suited to row crops if erosion is controlled. Small areas are managed with adjacent soils. This soil is low to moderately low in organic-matter content and fertility, but areas under cultivation are commonly in good tilth and easily worked. Erosion is a moderate hazard. (Capability unit IIe-3; woodland suitability group 3)

Colo Series

The Colo series consists of deep, dark-colored, poorly drained soils that formed in alluvium on first bottoms. These soils are near all the major streams and tributaries in the county, but they are most common along the benches of North River. They are nearly level and gently sloping. The native vegetation in most areas was prairie grasses, though in some areas there were trees that influenced the development of the soils.

Colo soils are in association with other dark-colored soils of the bottom lands. Normally, the Colo soils are between the fine-textured, more poorly drained Wabash or Zook soils that are near the outer boundaries of the bottom land and the moderately well drained Kennebec soils that are near the stream. In some areas, they are adjacent to soils on upland side slopes and foot slopes and soils on stream benches.

In a representative profile, the surface layer is black grading to very dark gray silty clay loam about 25 inches thick. The underlying layers are firm, very dark gray silty clay loam. At a depth of about 5 feet the material is stratified and some sand grains are present. It has a few brown mottles. The texture is finer, and mottling increases in the lower part. When this material is dry, gray coatings are present.

The Colo soils have high available water capacity and moderately slow permeability. They are high in organic-matter content and slightly acid in the surface layer unless limed. They are medium in available nitrogen and are medium to high in available phosphorus and potassium. These soils have a deep, favorable root zone.

Colo soils are easily tilled. They are suited to row crops, and most areas are managed as cropland with adjacent soils on bottom land. Many areas have meandering surface drains and small ponded areas. Most areas need some tile drainage to correct this condition. These soils are subject to flooding of varying frequency, but water does not stand for long periods.

Representative profile of Colo silty clay loam, 740 feet south and 1,460 feet west of the northeast corner of sec. 3, T. 76 N., R. 27 W., in a level cultivated field:

Ap—0 to 8 inches, black (10YR 2/1) light silty clay loam; dark gray (10YR 4/1) when dry; weak, fine, granular structure; friable; slightly acid (pH 6.4); clear, smooth boundary.

A11—8 to 18 inches, black (10YR 2/1) light silty clay loam; dark gray (10YR 4/1) when dry; weak, very fine, subangular structure; friable; slightly acid (pH 6.5); clear, smooth boundary.

A12—18 to 25 inches, very dark gray (10YR 3/1) silty clay loam; gray (10YR 5/1) when dry; weak, fine, subangular blocky structure; friable; discontinuous, grainy, gray coatings when dry; few, fine, tubular pores; slightly acid (pH 6.5); gradual, smooth boundary.

AC—25 to 39 inches, very dark gray (10YR 3/1) silty clay loam; few, fine, faint, brown (10YR 4/3) mottles; gray (10YR 5/1) when dry; weak, medium to fine, prismatic structure, breaking to weak, fine, angular blocky structure; firm; light gray (10YR 6/1) when dry; grainy coatings on ped faces; common tubular pores; slightly acid (pH 6.5); gradual, smooth boundary.

C—39 to 58 inches, very dark gray (10YR 3/1) silty clay loam; few, fine, faint, brown (10YR 4/3) mottles; weak, medium, prismatic structure, breaking to weak, fine, angular blocky structure; firm; light gray (10YR 6/1 and 7/1) when dry; grainy coatings on ped faces; few tubular pores; few, fine, yellowish-brown (10YR 5/6) concretions; slightly acid (pH 6.5).

The surface layer is typically silty clay loam but ranges to heavy silt loam in texture and from 18 to 30 inches in thickness. It ranges from black to very dark gray. Some areas contain very fine sand and recent light-colored deposition mixed in the surface layer. The underlying layer has a very dark gray to black color, but there is a wide range in amount of brown mottling. At a depth of more than 3 feet, the layers of gray and brown are more common. These layers are light to medium silty clay loam, and some areas have very thin strata mixed with fine sand. The underlying materials are commonly more sandy and range from silty clay loam having enough sand to give a gritty feel to clay loam at a depth between 4 and 6 feet.

Colo soils are better drained, more permeable, and less clayey in the underlying material than the poorly drained Zook soils or very poorly drained Wabash soils. They are grayer and more mottled in the underlying material than the Kennebec soils and are finer textured and more poorly drained.

Colo silty clay loam (0 to 2 percent slopes) (Cu).—This soil is on first bottoms and is in small areas near all the major streams of the county and their tributaries. It is not extensive, but it is locally important. It is in association with and adjacent to the Kennebec and Zook soils on first bottoms, and in some places it is adjacent to the Nevin and Wiota soils on second bottoms. This soil is dark colored and has moderately slow permeability. The surface layer usually absorbs water readily.

Included with this soil in mapping, where the soil material has a high content of fine sand, were small areas of Spillville soils. Very sandy areas and areas of sandy deposition are indicated on the soil map by the symbol for sand spot. Also included were small areas of the associated Kennebec and Zook soils.

This soil is well suited to row crops if wetness is controlled. Many areas have swales or surface drains that become ponded from flooding. The soil is normally in good tilth, however, and dries out more quickly than the fine-textured associated soils on bottom land. Most of this soil is in crops and is managed with adjacent soils. Some small areas that are not accessible to machinery are in pasture. (Capability unit IIw–1; woodland suitability group 11)

Colo silty clay loam, channeled (0 to 2 percent slopes) (Cv).—This soil is on first bottoms in narrow areas that include the stream itself. It is adjacent to Colo or Zook soils farther away from the stream, and it is frequently flooded.

The profile of this soil is similar to that described as representative for the Colo series, but it has a wider range in color and texture of the surface layer than is typical.

Included with this soil in mapping were areas of Kennebec, Spillville, and Zook soils and some recent sandy deposition.

This soil is unsuited to crops, because of the meandering stream within its boundaries. Streambank cutting is common, and short side gullies form at the edge of the stream channel. Access for farm machinery is very limited.

Most of the acreage is in wooded pasture. Small parts of some areas are managed as cropland with more suitable adjacent soils on either side of the stream. In some areas it would be practical to straighten the stream. With stream straightening and bank stabilization, this soil could be tilled close to the streambank and would compare favorable with other Colo soils in suitability for crops. (Capability unit Vw–1; woodland suitability group 11)

Colo-Ely silty clay loams, 2 to 5 percent slopes (CwB).—This complex consists of Colo and Ely soils that are in narrow, upland drainageways and along very small, intermittent streams in all parts of the county. These areas range from about 100 to 500 feet in width, and it was not practical to separate the different soils on the soil map.

The Colo soils make up about two-thirds of the acreage and are near the streams. The gently sloping Ely soils make up about one-third of the acreage and are on foot slopes adjacent to the drains.

Soils of both series have a thick, black to very dark gray silty clay loam surface layer and are silty clay loam in the underlying layers. The Colo soils are poorly drained, and the Ely soils are somewhat poorly drained.

Included with these soils in mapping were small areas of Judson, Kennebec, and Olmitz soils.

Because areas of this complex are narrow, most of them are managed with adjacent soils as either cropland or pasture. Most areas wide enough to be managed separately are in crops. The natural fertility of these soils is high.

Floodwater and runoff from adjacent slopes cause gullying and deposition of soil material on the surface layer. Many very narrow areas are left as grass waterways within areas of cropland. Tile drainage is needed for better growth of either crops or pasture. After drainage is improved and gullying and deposition are controlled, the larger areas of this soil are well suited to row crops. (Capability unit IIw–1; woodland suitability group 11)

Colo-Ely silty clay loams, gullied, 2 to 5 percent slopes (CyB).—These soils are along upland drainageways and very small upland streams in all parts of the county (fig. 13). The soils are in areas too small to be mapped separately.

Gullying is in the form of large central gullies or winding, stabilized, small streams where streambanks have eroded and short side gullies have formed. In many places these are dominant in more than half the total area.

This mapping unit differs from Colo silty clay loam, channeled, in that it includes some fine-textured soils and less poorly drained soils, and channeling and gullying are more severe. The channeling has been caused by severe gullying rather than by the meandering of streams. These Colo and Ely soils also are more exposed to runoff from upslope, and this results in side gullies or deposition.

These soils are not suited to crops. Fertility and tilth are good, but gullying is severe. In places where narrow streams level out, there are deposits of silt, clayey sediment, or sandy material washed down from gullies. Where gullies can be filled or smoothed, the soils should be kept in grass so that gullying can be controlled. Gully control, pasture improvement, tree planting, and the establishment of wildlife areas are practices that can be used to improve these soils. (Capability unit Vw–1; woodland suitability group 2)

Figure 13.—**Typical area of Colo-Ely silty clay loams, gullied, 2 to 5 percent slopes.**

Dunbarton Series, Deep Variant

The Dunbarton series, deep variant, consists of moderately deep, moderately dark colored soils that formed partly in thin layers of loess and partly in glacial till sediments underlain by clayey residuum and hard limestone bedrock. These soils of the uplands are moderately well drained. They are on upper side slopes and ridgepoints. The native vegetation was trees.

These soils are downslope and adjacent to the Clinton or Ladoga soils and upslope from Steep rock land and Nordness soils. They are in small areas along the North and Middle Rivers, most commonly in the east-central part of the county.

In a representative profile, the surface layer is very dark gray silt loam about 4 inches thick. The subsurface layer is dark grayish-brown silt loam about 7 inches thick. This layer is light brownish gray when dry. The upper part of the subsoil, about 4 inches thick, is brown silty clay loam. The lower part of the subsoil is firm and very firm, weathered silty clay and clay glacial till that is about 15 inches thick. The upper 4 inches is firm, brown silty clay and the lower 11 inches is very firm, reddish-brown and yellowish-red clay. These layers are underlain at a depth of about 30 inches by limestone bedrock.

Available water capacity is medium to low, depending on depth to limestone bedrock. Permeability is slow in the clayey part of the subsoil that formed in till, but it is moderate in the layers that formed in loess. In areas that are less than 30 inches deep to bedrock, these soils are somewhat droughty. The root zone is shallow because of the very firm clay layer and lack of available moisture. The organic-matter content is low, and these soils are low to very low in available nitrogen and phosphorus and medium in available potassium. They are normally medium acid to very strongly acid in the surface layer and the upper part of the subsoil unless limed.

Most areas of these soils are in pasture, but some areas are managed as cropland with the more suitable Ladoga and Clinton soils that are upslope on ridgetops. Other areas are managed as pasture or left in trees.

The Dunbarton soils, deep variant, tend to be droughty, but the hazard of erosion is the main concern of management. The surface and subsurface layers absorb water well, but there is rapid runoff because of the very slowly permeable lower part of the subsoil. Tilth commonly is good, except in areas of severe erosion.

Representative profile of Dunbarton silt loam, deep variant, 9 to 14 percent slopes, moderately eroded, 380 feet south and 100 feet east of the northwest corner of sec. 4, T. 75 N., R. 27 W., in a pasture on a short ridgepoint having a slope of 9 percent:

A1—0 to 4 inches, very dark gray (10YR 3/1) silt loam; weak, fine, granular structure; friable; slightly acid (pH 6.5); clear, smooth boundary.
A2—4 to 11 inches, dark grayish-brown (10YR 4/2) silt loam; grainy coatings, light brownish gray (10YR 6/2) when dry; weak, very fine, platy structure, breaking to weak, very fine, subangular blocky structure; friable; medium acid (pH 6.0); gradual, smooth boundary.
B1—11 to 15 inches, brown (10YR 4/3) light silty clay loam; faces of peds dark grayish brown (10YR 4/2); weak, fine, subangular blocky structure; friable; grainy coatings, light brownish gray (10YR 6/2) when dry; medium acid (pH 5.6); clear, smooth boundary.
IIB21t—15 to 19 inches, brown (7.5YR 4/4), silty clay; faces of peds brown (7.5YR 4/2); moderate, fine, angular blocky structure; firm; thin, discontinuous clay films; very strongly acid (pH 4.8); clear, smooth boundary.
IIB22t—19 to 30 inches, reddish-brown (5YR 4/4) and yellowish-red (5YR 4/6) clay; few, fine, faint, strong-brown (7.5YR 5/6) mottles; moderate, medium, prismatic structure breaking to moderate, fine and very fine, angular blocky structure; very firm; thick, continuous clay films; slightly acid (pH 6.5); abrupt, wavy boundary.
IIIR—30 inches +, limestone bedrock.

The surface layer ranges from 3 to 5 inches in thickness and from very dark gray to very dark grayish-brown in color. The subsurface layer ranges from 5 to 8 inches in thickness. The upper part of the subsoil formed in loess or glacial sediments and has little range in color. This layer ranges from 3 to about 7 inches in thickness. The lower part of the subsoil is reddish-brown, strong-brown, and brown clay or silty clay. Most of it is mixed with yellowish red, but some is mixed with yellowish brown and olive gray. This layer ranges from 13 to 20 inches in thickness. Depth to hard limestone bedrock ranges from 20 to 40 inches. The Dunbarton soils in Madison County were mapped as a deep variant because they are underlain by hard limestone at a greater depth than is typical for the series.

The Dunbarton soils, deep variant, differ from the Keswick soils in that they have a more silty surface layer and are underlain by hard limestone bedrock at a depth of about 30 inches. Dunbarton soils, deep variant, are deeper to limestone bedrock than the Nordness soils. In addition, they have a clayey subsoil and are not so droughty as the Nordness soils.

Dunbarton silt loam, deep variant, 9 to 14 percent slopes, moderately eroded (DbD2).—This sloping soil is in parts of the county where limestone outcrops are on upper side slopes, and it occupies ends of ridges on narrow loess-covered ridgetops. It is downslope from the Clinton and Ladoga soils and upslope and adjacent to Nordness soils or Steep rock land.

In some areas the profile of this soil has thinner and lighter colored surface and subsurface layers than the profile described for the series.

Erosion has removed much of the surface layer and the subsurface layer is exposed in some areas of pasture and timber. In cultivated areas these layers are mixed by plowing. The combined thickness of the surface and subsurface layers averages 8 to 13 inches.

Included with this soil in mapping were areas with a thicker surface layer and small, severely eroded areas. Also included were narrow bands of adjacent soils near the boundaries of areas mapped as this soil. Limestone fragments up to 12 inches in size are common on the surface near the boundary with Steep rock land.

This soil is poorly suited to row crops even if erosion is controlled. It is low in organic-matter content, and severely eroded spots have poor tilth. Most areas are in pasture.

This soil is droughty in some years, but erosion is the major concern in management of the soil. If erosion is checked, the soil generally can be farmed with more suitable soils. In some areas, however, this soil is better suited to woodland or wildlife habitat than to crops because the areas are small, the soil is droughty, and it is subject to severe erosion. (Capability unit IVe-3; woodland suitability group 2)

Ely Series

The Ely series consists of deep, dark-colored, somewhat poorly drained soils that formed in local alluvium eroded from adjacent upland side slopes. These soils have slopes that range from 2 to 5 percent. They occur in all parts of the county but are most common in the western and southern parts. These gently sloping soils are in convex, fan-shaped areas at the foot of drainageways or on narrow, flat to concave foot slopes at the base of the upland slopes. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black light silty clay loam and very dark gray silty clay loam about 32 inches thick. The subsoil is dark grayish-brown and grayish-brown, friable silty clay loam, about 22 inches thick, that has yellowish-brown and brown mottling. The subsoil also contains some very dark gray. The substratum is light silty clay loam or light clay loam below a depth of about 54 inches. Color and mottling are similar to those in the subsoil. The detailed profile is not described to a depth great enough to show the substratum.

The Ely soils have high available water capacity. They are moderate in permeability. In places they receive seepage water. These soils have high organic-matter content and absorb water readily. They are low to medium in available nitrogen, low in available phosphorus, and medium to high in available potassium. They have a deep, favorable root zone. Typically, these soils are medium acid in the surface layer unless limed.

Ely soils are fertile and suited to crops. Most individual areas are too small to be managed separately. Most of the larger areas are managed with adjacent soils on bottom lands, and the smaller areas are managed with adjoining soils on uplands. Most of the acreage is in crops.

Representative profile of Ely silty clay loam, 2 to 5 percent slopes, 240 feet west and 420 feet south of the northeast corner of sec. 3, T. 76 N., R. 27 W., in a cultivated field on a foot slope of 3 percent:

Ap—0 to 9 inches, black (10YR 2/1) light silty clay loam; weak, fine, granular structure; friable; medium acid (pH 5.7); clear, smooth boundary.
A1—9 to 18 inches, black (10YR 2/1) light silty clay loam; weak to moderate, fine, subangular blocky structure; friable; medium acid (pH 5.7); gradual, smooth boundary.
A3—18 to 32 inches, very dark gray (10YR 3/1) silty clay loam; weak, medium, prismatic structure, breaking to weak, fine, subangular blocky structure; friable; slightly acid (pH 6.4); gradual, smooth boundary.
B2—32 to 39 inches, dark grayish-brown (10YR 4/2) and some very dark gray (10YR 3/1) medium silty clay loam; common, fine, distinct, brown (10YR 5/3) and yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure, breaking to weak, fine, subangular blocky structure; friable; neutral (pH 6.6); gradual, smooth boundary.
B3—39 to 54 inches, grayish-brown (10YR 5/2) and some very dark gray (10YR 3/1) light silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles;

brown (10YR 5/3) ped interiors; weak, medium, prismatic structure, breaking to weak, fine, subangular blocky structure; friable; very few clay flows in pores; neutral (pH 6.6).

The combined thickness of the surface layer and subsoil ranges from 40 to 60 inches. The surface layer ranges from 24 to 36 inches in thickness. In most areas this layer is black, but in some it is covered to plow depth by more recent deposition. These more recent layers are gray or grayish brown and generally contain more fine sand than the older surface layer. The subsoil ranges from 15 to 30 inches in thickness and from grayish brown to dark grayish-brown light loam to medium silty clay loam. There is a wide range in the amount of very dark gray in the subsoil. The abundance of yellowish-brown mottles ranges from few to common, and they have a wide range in size. Coarser sand particles are in some places in the lower subsoil and substratum. The substratum ranges from silty clay loam to clay loam and has a very wide range in the color and amount of mottling.

The Ely soils are more poorly drained, grayer colored, and more mottled in the subsoil than the Judson soils. They contain less sand, are not as brown in the subsoil, and are not as well drained as the Olmitz soils. The Ely soils are better drained than the Zook soils. Ely soils have a thicker surface layer than the Nevin soils and lack the increase in clay content from the surface layer to the subsoil.

Ely silty clay loam, 2 to 5 percent slopes (EIB).—This gently sloping soil is on alluvial foot slopes at the base of hill slopes. Also, some areas are on alluvial fans at the end of long drainageways. This soil is upslope from and adjacent to the Colo and Zook soils on first bottoms and downslope from areas of the Lamoni and Shelby soils. Some areas are underlain by sand at a depth of about 8 feet.

Included with this soil in mapping were small areas of the Judson, Olmitz, and the gently sloping Zook soils.

This soil is well suited to row crops. It is productive, and the surface layer is normally in good tilth. Limitations for crops are minor, and the hazard of erosion is only slight. This soil receives runoff from adjacent slopes, and some drainageways tend to gully slightly during heavy rains. The runoff from adjacent slopes leaves silt and fine sand on the surface of this soil. In some places, this deposition creates greater problems than erosion.

Most areas of this soil need some tile drains for better crop growth. Diversion terraces at the base of side slopes also benefit this soil. If wetness is corrected and excess runoff from side slopes is safely removed, this soil is well suited to row crops. (Capability unit IIw-1; woodland suitability group 8)

Flaggy Alluvial Land

Flaggy alluvial land (0 to 2 percent slopes) (Fg) is on narrow bottoms of small streams in the central part of the county, most commonly in areas where limestone crops out. This land type consists of loamy to sandy alluvium that contains many fragments of limestone from nearby ledges. These fragments are flaggy. They range from 2 to 10 inches in diameter and from one-half inch to 2 or 3 inches in thickness and are irregular in shape.

This land type commonly is adjacent to areas of Steep rock land, and the limestone fragments are stratified with coarse sand and loamy material. In wider areas it is adjacent to and includes small areas of Spillville loam, flaggy substratum. Most areas are long and narrow. They include stream channels that are quite straight but are subject to severe streambank cutting that exposes the stratified rock fragments.

This land type is somewhat droughty, but it is subject to flash floods from fast-moving runoff from the adjacent steep and very steep, rocky side slopes. Water recedes quickly and leaves new deposits of sand and fragmented rock after each flood.

Areas of Flaggy alluvial land have very rocky streambeds. During very hard rains, large fragments of limestone are deposited in these channels. Some streams are spring fed, but most are dry between rains.

This land type is not suited to crops of any kind and has very severe limitations for pasture. Tree roots can penetrate the stratified layers, but grass roots are very shallow. Side drains form medium to large, rocky ravines, and these limit access for livestock. Flaggy alluvial land is suited to woodland and wildlife habitat. (Capability unit Vw-1; woodland suitability group 2)

Gara Series

The Gara series consists of deep, moderately dark colored, moderately well drained soils of the uplands that formed in glacial till under prairie grasses and trees. These soils are on the crests of narrow ridges, where slopes are 5 to 9 percent, and on side slopes where slopes are 9 to 40 percent. Most areas of Gara soils are on side slopes of 14 percent or more. Individual areas are typically large and are along all main tributaries of the major streams. In addition, many of them are adjacent to the major streams.

The Gara soils are adjacent to and downslope from the Ladoga, Lamoni, and Keswick soils (fig. 14). In some places they are downslope from the Sharpsburg and Clinton soils. In the central and eastern parts of the county, Gara soils are upslope from soils that were derived from limestone and shale. Among these are the Nordness, Clanton, and Gosport soils.

In a representative profile, the surface layer is very dark gray loam about 7 inches thick. The subsurface layer is loam about 4 inches thick. It is dark grayish brown when moist and light brownish gray when dry. The subsoil, to a depth of about 32 inches, is yellowish-brown to brown, firm clay loam. The lower part of the subsoil is light brownish-gray, firm clay loam that has many yellowish-brown and strong-brown mottles. Free lime (concretions of white carbonate) are at a depth of about 38 inches. The substratum is not shown in the detailed description of the representative profile.

The Gara soils have high available water capacity and moderately slow permeability. The surface layer takes in water readily, but because of the compact subsoil and the slope of Gara soils, runoff ranges from medium to rapid. The hazard of erosion is severe, and gullies form readily if vegetation such as trees or grass is thin or is absent. Gara soils are slightly acid to strongly acid in the surface layer unless limed, and they are medium in organic-matter content. They are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium. These soils have a deep, favorable rooting zone.

The less sloping Gara soils can be safely used for cropland if erosion is controlled. Most other areas, depending

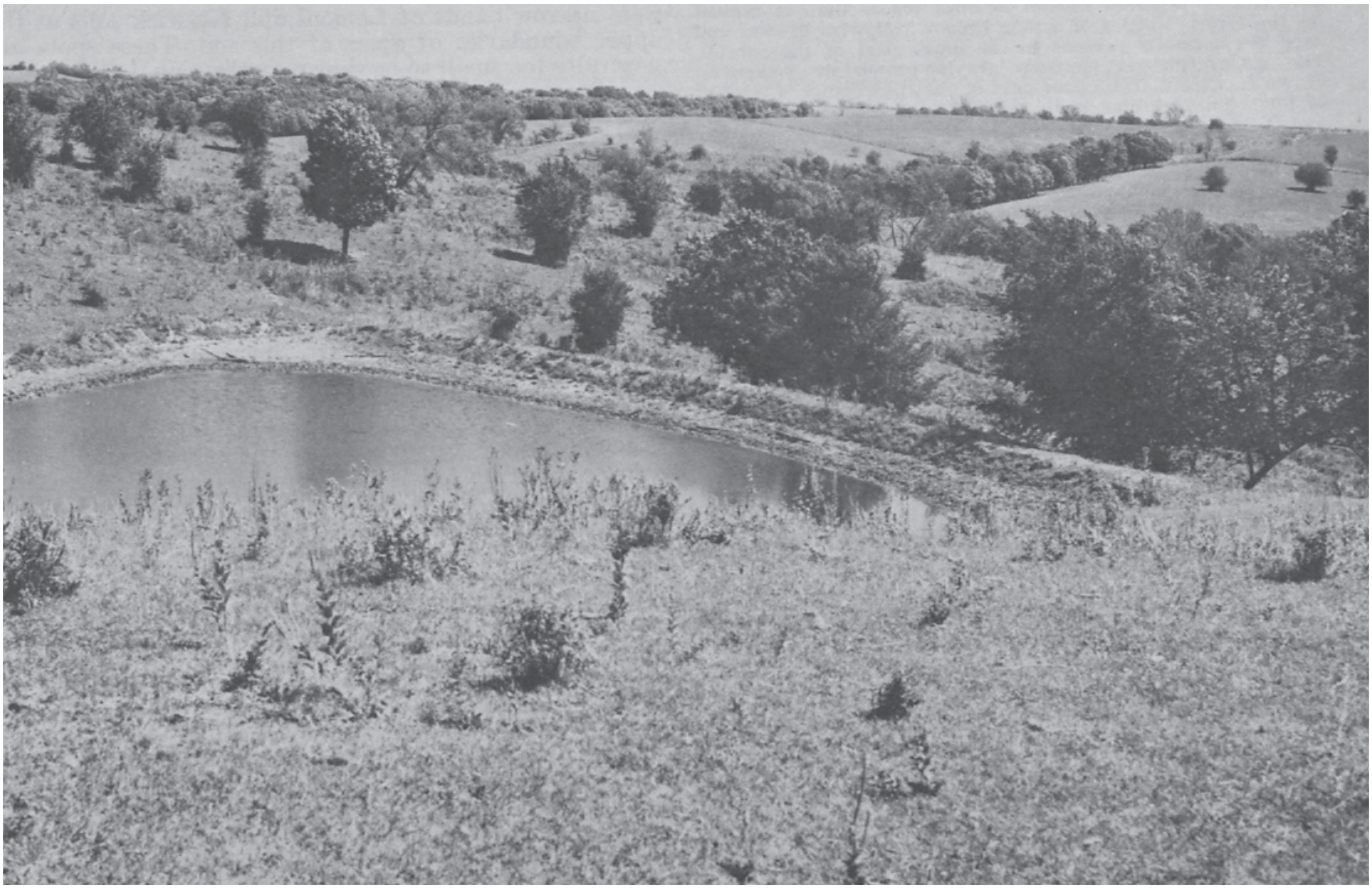

Figure 14.—Area of a Gara soil in pasture. Ladoga soils are on ridgetops in background.

on steepness and irregularity of slope, are used for pasture, woodland, or wildlife habitat.

Representative profile of Gara loam, 18 to 25 percent slopes, moderately eroded, 175 feet south and 780 feet east of the northwest corner of sec. 29, T. 75 W., R. 28 W., in a timber pasture on a northwest-facing slope of 18 percent:

A1—0 to 7 inches, very dark gray (10YR 3/1) loam; moderate, very fine, granular structure; friable; slightly acid (pH 6.3); clear, smooth boundary.

A2—7 to 11 inches, dark grayish-brown (10YR 4/2) loam; light brownish gray (10YR 6/2) when dry; grainy coatings, light gray (10YR 7/2) when dry; weak, medium, platy structure to moderate, fine, granular structure; friable; medium acid (pH 5.7); clear, smooth boundary.

B1t—11 to 17 inches, yellowish-brown (10YR 5/4) clay loam; faces of peds dark grayish-brown (10YR 4/2); brown (10YR 5/3) when kneaded; moderate, fine, angular and subangular blocky structure; firm; dark grayish-brown, nearly continuous, grainy coatings; thin, discontinuous clay films; few pebbles; strongly acid (pH 5.2); clear, smooth boundary.

B21t—17 to 25 inches, yellowish-brown (10YR 5/4) heavy clay loam; faces of peds brown (10YR 4/3); weak, medium, subangular blocky structure, breaking to moderate, fine and very fine, subangular and angular blocky structure; firm; few, discontinuous, grainy coatings; thin, nearly continuous clay films; common pebbles; strongly acid (pH 5.3); gradual, smooth boundary.

B22t—25 to 32 inches, brown (10YR 5/3) heavy clay loam; few, fine, distinct, yellowish-brown (10YR 5/4) mottles and few, fine, faint, grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; firm; thin, continuous clay films; few, black, organic coatings in root channels; common pebbles; medium acid (pH 5.7); gradual, smooth boundary.

B23t—32 to 38 inches, light brownish-gray (2.5Y 6/2) clay loam; faces of peds grayish brown (2.5Y 5/2); common, fine and medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm; thin, continuous clay films; few, fine and medium, black concretions of an oxide; dark organic stains in root channels; common pebbles; slightly acid (pH 6.2); abrupt, smooth boundary.

B3t—38 to 50 inches, light brownish-gray (2.5Y 6/2) light clay loam; common, fine, distinct, yellowish-brown (10YR 5/4) and strong-brown (7.5YR 5/6) mottles; weak, coarse, to moderate, medium, subangular blocky structure; firm; few, thin, discontinuous clay films; fine to medium carbonate concretions; few, fine, brown concretions; common pebbles; moderately alkaline (pH 8.0).

The color of the surface layer depends upon past management. The surface layer in undisturbed areas of timber is nearly black, and in cultivated areas it is lighter because of erosion and loss of organic matter. The combined thickness of the surface and subsurface layers is typically 7 to 12 inches. Consequently, in eroded areas material from these two layers is mixed in plowing and the subsurface layer is exposed in some places. The subsoil ranges from 24 to 40 inches or more in thickness. The Gara soils in this county have a finer textured subsoil in most places than is typical for the series. Mottles of strong brown, yellowish brown, and gray are normally present in the lower part of the subsoil. The substratum is mottled, grayish-brown or yellowish-brown clay loam. The upper part of the substratum is leached of lime, but free lime is in this layer at depths between 30 and 50 inches.

The Gara soils differ from Shelby soils in having a lighter colored, thinner surface layer and a higher content of clay in the subsoil. They have a grayish subsurface layer that is absent in Shelby soils. They have a thicker, darker colored surface layer and a less pronounced subsurface layer than the Lindley soils.

Gara loam, 5 to 9 percent slopes, moderately eroded (GaC2).—This soil is in small areas in the zones of transition between timber and prairie throughout the county. It is moderately sloping on side slopes and is downslope from the Ladoga soils. In a few places Keswick or Lamoni soils are upslope. In places this soil is adjacent to Clinton soils on narrow ridges and in most places is adjacent to and upslope from the steeper Gara soils.

The profile of this soil is similar to that described as representative for the series, but it has a very dark grayish-brown surface layer, lacks a subsurface layer, is shallower to the subsoil, and is commonly more mottled in the subsoil.

The surface layer is 3 to 7 inches thick. In places the surface layer and some of the upper part of the subsoil have been mixed by plowing. In small areas the subsoil is exposed. Where these areas are significant, they are indicated on the soil map by the symbol for severely eroded spots.

Included with this soil in mapping were small areas of the Lamoni or Keswick soils near the upper boundaries of areas mapped as this soil. Where these inclusions are significant, they are indicated on the soil map by the symbol for clay spots.

Individual areas of this soil are small, and most of them are managed with the adjacent Ladoga soils as cropland. Some are managed as pasture with soils that are less suitable for cropland.

This soil is subject to erosion. It is moderately suited to row crops if erosion is controlled. Soil tilth is normally good, except in the severely eroded areas. These areas tend to be cloddy and hard when they are dry. (Capability unit IIIe-3; woodland suitability group 4)

Gara loam, 9 to 14 percent slopes, moderately eroded (GaD2).—This strongly sloping soil is mainly on convex ridges that extend down from the narrow, loess-mantled divides. It also occurs in narrow bands along side slopes, and here it is downslope from the Ladoga soils. On hillsides the soil is crossed by waterways that make the slopes irregular. This soil is upslope from steeper Gara soils, and in some areas it is adjacent to and upslope from Nordness, Clanton, or Gosport soils. Some areas of this soil are adjacent to and downslope from Keswick or Lamoni soils. In a few places this soil occupies convex, sloping ridgepoints and extends down to high benches above stream bottoms.

The profile of this soil is similar to that described as representative for the series, but it has a 3- to 7-inch surface layer that is very dark grayish brown. The grayish subsurface layer is absent in places or is mixed with the surface layer.

Included with this soil in mapping were small areas where the subsoil is exposed in plowing. Also included were narrow bands of Lamoni and Keswick soils at the upper boundaries of areas of this soil. These spots are generally too small to be shown on the map, but the more significant areas are indicated by the symbols for severely eroded spots and for clay spots. Where this soil is above limestone or shale, small spots of these materials were included. If these spots are important to management, they are shown on the map by the symbols for rock outcrops and for shale outcrops.

This soil is used for both cropland and pasture. Because it occupies areas of irregular shape, it is not managed separately but generally is managed with the adjacent Ladoga soils or other Gara soils.

This soil is poorly suited to row crops. The thin surface layer, the compact, moderately slowly permeable subsoil, and the strong slopes cause runoff to be rapid. Erosion is therefore a serious hazard. Gullies form easily, and stones may be exposed on the surface and hinder cultivation. This soil is low in available plant nutrients, especially nitrogen and phosphorus. Controlling erosion, maintaining good tilth, and improving fertility are the major concerns in managing this soil. (Capability unit IVe-2; woodland suitability group 4)

Gara loam, 14 to 18 percent slopes (GaE).—This soil is mainly near streams where the topography is rough and hills are partially wooded. It typically occurs as bands along hillsides, downslope from the Ladoga soils on the ridges. These areas have a wide range in width and slope characteristics and have many sidehill drainageways. This soil is upslope from the steeper Gara soils and the Nordness, Gosport, or Clanton soils. In some places this soil is downslope from the Lamoni soils or the less sloping Gara soils. In other places it is upslope from and adjacent to the Olmitz or Ely soils or the Colo-Ely silty clay loams.

This soil has a profile similar to the one described as representative for the series. The total thickness of the surface and subsurface layers is generally about 10 inches, but in some areas this thickness is greater or less.

Included in mapping were small areas of the Lamoni soils and areas of other Gara soils. Where this soil is upslope from Nordness, Gosport, or Clanton soils, very small areas of these soils were also included.

Most of this soil is in pasture or wooded pasture. It produces fair pasture that, in many places, can be improved by liming, fertilizing, and reseeding to more productive grasses and legumes. This soil is not suited to row crops, because of the moderately steep slopes and inherent low fertility.

This soil is not seriously eroded. If it is plowed, however, runoff is rapid and sheet erosion and gullying can be severe. Shrubs and brush grow in some areas, and clearing of these woody plants will improve pastures. Hillside waterways are mostly well stabilized, but in places some control of gullying is needed. (Capability unit VIe-2; woodland suitability group 4)

Gara loam, 14 to 18 percent slopes, moderately eroded (GaE2).—This is the most extensive Gara soil in the county. It is on side slopes that are downslope from Ladoga soils on ridgetops and upslope from the Colo-Ely silty clay loams along large drainageways. Hillside waterways run through it, and consequently the slopes are irregular. In areas of steeper topography, this soil is downslope from Lamoni, Keswick, or less sloping Gara soils, and upslope from steeper Gara soils or Nordness, Gosport, or Clanton soils.

Areas of this soil have a wide range in size and shape. Some occupy entire hillsides. Others occur as narrow, irregular bands along hillsides and around ends of ridges that are upslope from steeper soils.

The profile of this soil is similar to that described as representative for the series, but it has a very dark grayish-brown surface layer. The remaining surface layer ranges from 3 to 7 inches in thickness and is mostly loam but ranges to clay loam. The loss of organic matter and some mixing of the surface layer with the subsurface layer and subsoil give this soil a browner color.

Included with this soil in mapping were many small areas or spots of Lamoni and Keswick soils. Also, because mapped areas of this soil have irregular shapes and slopes, small areas of Arbor soils and other Gara soils were included. Other inclusions are small areas of Colo and Ely soils along waterways. Hillside waterways generally are gullied or are starting to gully. Stones are on the surface in many places. An erosion symbol is used on the soil map to indicate severely eroded spots of significant size.

Some areas of this soil are large enough to be managed separately, but smaller areas are managed, where practical, with adjacent soils. Some areas are used for cultivated crops, but this soil is not suited to such use. Much of this soil is in pasture, and some is in wooded pasture.

Because of a thin surface layer and moderately steep slopes, runoff is rapid if this soil is cultivated. Sheet and gully erosion is too great a hazard for this soil to be used for crops. Suitable pasture can be grown if it is well managed. (Capability unit VIe-2; woodland suitability group 4)

Gara loam, 18 to 25 percent slopes, moderately eroded (GaF2).—This steep Gara soil formed in glacial till that has been exposed on side slopes. It generally is downslope from less sloping Gara soils and upslope from alluvial soils on foot slopes or stream bottoms. It is most common in the southern one-third of the county, along Grand River, South River, Clanton Creek, and their tributaries. In some areas in the central and northeastern parts of the county, this soil occurs upslope from and adjacent to Nordness, Gosport, or Clanton soils. In some areas it occupies the entire side slope below narrow ridgetops occupied by Clinton and Ladoga soils.

The profile of this soil is the one described as representative for the series. In some timbered areas the soil has a very dark grayish-brown loam surface layer. Cleared areas in pasture are more eroded and lighter (grayer) colored because the content of organic matter is low or the surface layer has been eroded away. In these areas the surface layer is only 3 to 8 inches thick and is less friable than normal.

Included in mapping were small areas that are less sloping than this Gara soil and small areas that are steeper. Significant inclusions, such as limestone and shale outcrops, are shown on the soil map by spot symbols. Included severely eroded areas are shown on the soil map by the symbol for severely eroded spots.

Most of this soil is in large areas. Much of it is in timber pasture, but some small areas are entirely cleared. This soil is too steep for cultivated crops. The steep, irregular slopes make the use of farm machinery hazardous, and pastures therefore are hard to improve or renovate. The carrying capacity of pastures is low. This soil is suited to woodland.

Because runoff is rapid, erosion is a severe hazard. (Capability unit VIIe-1; woodland suitability group 5 or 6)

Gara loam, 25 to 40 percent slopes (GaG).—This very steep Gara soil is on side slopes. It is downslope from and adjacent to less steep Gara soils or is in small areas within larger areas of these soils. In a few places it occupies entire hillsides.

This soil has a profile similar to the one described as representative for the series, but the subsoil typically is not so thick. In places at a depth ranging from 24 to 30 inches, there is free lime, or carbonates.

Included in mapping were small areas of adjacent soils. Significant areas of shale and limestone are in a few places, and these areas are indicated by spot symbols on the soil map.

This soil is not suitable as cropland and has severe limitations for pasture. It is almost entirely covered by hardwood trees of many kinds, mainly oak and elm. Areas that have been cleared are subject to very rapid runoff and severe erosion, and cleared pastures are normally poor. This soil contains more large, stabilized ravines than do other Gara soils. The slopes are too steep for the safe operation of farm equipment. (Capability unit VIIe-1; woodland suitability group 5 or 6)

Givin Series

The Givin series consists of deep, somewhat poorly drained, moderately dark colored soils that formed in loess on uplands. These nearly level soils are on ridgetops and high benches close to major streams. The native vegetation was grass and trees.

The Givin soils are adjacent to and upslope from the gently sloping Ladoga soils. In places they are adjacent to the Macksburg soils, which are in similar positions on the landscape but formed under prairie vegetation.

In a representative profile, the surface layer is very dark gray to very dark grayish-brown silt loam about 8 inches thick. Below this is a more silty, lighter colored subsurface layer. It is friable silt loam about 6 inches thick that is dark gray and dark grayish brown when moist and light gray when dry. The subsoil is friable, dark grayish-brown silty clay loam in the upper 7 inches, dark grayish-brown and grayish-brown, firm light silty clay to a depth of about 34 inches, and light brownish-gray silty clay loam below 34 inches. It is mottled with gray, yellowish brown, and strong brown. The mottling increases with depth. The substratum, which is not described in the detailed description of the representative profile, is similar in color and texture to the lower part of the subsoil.

The Givin soils have high available water capacity and are moderately slow in permeability. They are typically medium or strongly acid in the surface layer unless limed, and they are medium in organic-matter content. These soils are low in available nitrogen, very low to low in available phosphorus, and normally low to medium in available potassium. They have a deep, favorable root zone for plants.

Individual areas of Givin soils have a wide range in size. Some large areas, especially on benches, are managed separately. Most of the acreage is in cultivation, and row crops are grown. Tile drainage is needed in some areas. In most places the hazard of erosion is not serious.

Representative profile of Givin silt loam, 10 feet south and 70 feet west of the northeast corner of sec. 25, T. 76 N., R. 27 W., in a cultivated field on a level ridgetop:

Ap—0 to 8 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) silt loam; light brownish gray (10YR 6/2) when dry; weak, coarse, platy structure, breaking to weak, fine, granular structure; friable; the plow layer incorporates about 2 inches of an original A2 horizon; neutral (pH 6.8); clear, smooth boundary.

A2—8 to 14 inches, dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) light silty clay loam; light gray (10YR 6/1) when dry; weak, medium, platy structure, breaking to weak, fine, subangular blocky structure; friable; few sand grains on ped faces; slightly acid (pH 6.2); gradual, smooth boundary.

B1t—14 to 21 inches, dark grayish-brown (10YR 4/2) silty clay loam; moderate, fine, subangular blocky structure; friable; discontinuous grainy coatings on ped faces, light gray (10YR 7/2) when dry; thin, discontinuous clay films; strongly acid (pH 5.2); gradual, smooth boundary.

B21t—21 to 27 inches, dark grayish-brown (10YR 4/2) light silty clay; common, medium, faint, yellowish-brown (10YR 5/4) mottles; light gray (10YR 7/2) when dry; weak, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; firm; thin, continuous clay films on ped faces; strongly acid (pH 5.2); gradual, smooth boundary.

B22t—27 to 34 inches, grayish-brown (10YR 5/2) light silty clay; many, medium, faint, yellowish-brown (10YR 5/4) mottles; weak, medium, prismatic structure, breaking to weak, fine, subangular blocky structure; firm; thin, discontinuous, dark-gray (10YR 4/1) clay films on ped faces and in root channels; common dark oxides; strongly acid (pH 5.2); gradual, smooth boundary.

B3t—34 to 50 inches, light brownish-gray (10YR 6/2) silty clay loam; many, medium, distinct, yellowish-brown (10YR 5/6) mottles; friable; thin, discontinuous clay films on vertical ped faces and in root channels; relict, deoxidized, and leached weathering zone; common, dark oxides; medium acid (pH 5.9).

The surface layer ranges from 6 to 10 inches in thickness and is nearly black in some areas. The texture ranges from silt loam to light silty clay loam. The underlying subsurface layer ranges from 4 to 8 inches in thickness and is dark gray to gray or dark grayish brown in color. The middle part of the subsoil ranges from heavy silty clay loam to light silty clay. There is a wide range in the kind and the amount of mottling. The middle and lower parts of the subsoil ranges from 20 to 36 inches in combined thickness. The substratum ranges from light brownish gray to olive gray and shows a wide range in the amount and color of mottling. On benches, the underlying strata contain sand at depths of more than 4 feet.

Givin soils differ from Macksburg soils in having a thinner surface layer that is silt loam in texture and a dark-gray subsurface layer. They are more poorly drained and have grayer colors in the subsoil than the Ladoga soils. Givin soils differ from the Nevin soils in having a thinner surface layer, a dark-gray subsurface layer, and a more clayey subsoil. Givin soils have a thinner surface layer and are also higher in clay content in the subsoil than the Vesser soils.

Givin silt loam (0 to 2 percent slopes) (Gn).—This nearly level soil is on high ridgetops near the major streams of the county. It is upslope from and adjacent to the more sloping Ladoga soils. In some places near the major streams, this soil is adjacent to the Clinton soils. The profile of this soil is the one described as representative for the series.

Included with this soil in mapping were very small areas of gently sloping Ladoga soils and other adjacent soils. Also included were a few areas of soils more poorly drained than this soil.

This soil is well suited to row crops, but some areas are small and narrow and are managed with adjacent soils as pasture. The soil tilth is normally good. Some of the more poorly drained areas need tile drainage. Runoff is slow, and the hazard of erosion is only slight. (Capability unit I–2; woodland suitability group 8)

Givin silt loam, benches (0 to 2 percent slopes) (Go).—This soil is on high, level benches near major streams and is most common along the Middle River. It is adjacent to the Nevin and Wiota soils on second bottoms that are slightly lower in elevation. Near the streams this soil adjoins short, steep escarpments that drop sharply to first bottoms. Near the steeper uplands, it is normally adjacent to the Gara or Ladoga soils.

The profile of this soil is similar to that described as representative for the series, but it is on benches and has a wider range in color and texture in the substratum.

The surface layer ranges from nearly black to very dark gray. In some areas the dark-gray subsurface layer is not very evident except when the soil is dry. In some places the surface layer of this soil is light silty clay loam. The subsoil ranges from heavy silty clay loam to light silty clay, and has a wide range of gray and brown mottling. It is normally dark grayish brown but has some layers of grayer or browner colors. The underlying strata are loamy to sandy. The loess mantle on the bench ranges from 4 to 8 feet in thickness. The substratum is partly alluvial material in places where the loess is thinnest.

Included with this soil in mapping were small areas of Nevin and Wiota soils and some areas of gently sloping Ladoga soils on benches near drainageways. Also included were small areas of Vesser soils.

This soil is well suited to row crops. Some areas are large enough to be managed separately, but most are managed with the adjacent soils.

The tilth of this soil is normally good. The internal drainage is typically somewhat poor, but some small areas of moderately well drained and poorly drained soils are in the mapping unit. The more poorly drained areas need tile drainage. The hazard of erosion is only slight. (Capability unit I–2; woodland suitability group 8)

Gosport Series

The Gosport series consists of deep, moderately dark colored, clayey soils that formed in material derived from brown and gray shale on uplands. Natural drainage is difficult to determine, but these soils are considered to be moderately well drained. They are on side slopes, where slopes are 14 to 25 percent, along major streams and their tributaries in the eastern part of the county. They are downslope from the Gara and Lindley soils and extend to the base of the slopes. In many places these soils are intermingled with and are adjacent to the Clanton soils. The native vegetation was mainly trees, but in some areas it was grass and trees.

In a representative profile, the surface layer is very dark grayish-brown silt loam about 6 inches thick. This is underlain by a dark grayish-brown silt loam subsurface layer that is about 7 inches thick and is light gray when dry. The subsoil is typically grayish-brown and light brownish-gray silty clay loam about 23 inches thick. It contains some light-gray and yellowish-brown mottling in the lower part. The subsoil is underlain by firm, gray silty clay loam and shale. It has yellowish-brown, brown, and strong-brown mottling.

The Gosport soils have medium to low available water capacity and are very slow in permeability. The subsoil and substratum are not a favorable root zone. Roots that do penetrate the shale provide channels that improve the water intake. Gosport soils are medium acid to strongly acid in the surface layer unless limed, are low in organic-matter content, and are very low in available nitrogen, phosphorus, and potassium. Runoff commonly is rapid, but it is very rapid if these soils are cleared of timber. The hazard of erosion is very serious, and gullies are readily formed.

The Gosport soils tend to be droughty because of the restricted water capacity. They are not suited to crops, and they have severe limitations for pasture. These soils are commonly used for woodland and wildlife habitat because of steepness of slope, low fertility, and unfavorable subsoil characteristics.

Representative profile of Gosport silt loam, 14 to 18 percent slopes, 125 feet east and 1,075 feet south of the northwest corner of sec. 17, T. 76 N., R. 26 W.:

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) medium silt loam; grayish brown (10YR 5/2) when dry; weak, medium, platy structure, breaking to weak to moderate, very fine, subangular blocky structure; friable; neutral (pH 6.8); clear, smooth boundary.

A2—6 to 13 inches, very dark grayish-brown (10YR 3/2) silt loam; light gray (10YR 7/2) when dry; weak, medium, platy structure, breaking to moderate, fine, subangular blocky structure; friable; this horizon contains more shale-derived material than the A1 horizon; strongly acid (pH 5.3); clear, smooth boundary.

B1—13 to 19 inches, grayish-brown (10YR 5/2) light silty clay loam; faces of peds dark grayish brown (2.5Y 4/2); moderate to strong, medium, subangular blocky structure; friable; color partly inherited from shale; few, weakly cemented, sandy shale fragments; discontinuous grainy coatings on faces of peds; medium acid (pH 5.6); clear, smooth boundary.

B21t—19 to 26 inches, grayish-brown to brown (10YR 5/2 to 10YR 5/3) heavy silty clay loam; moderate, medium, subangular blocky structure; thin, discontinuous clay films; firm; common, fine, tubular pores; color partly inherited from shale; few, weakly cemented, sandy shale fragments with brownish-yellow (10YR 6/8) oxide stains on broken surfaces; discontinuous silt coats on faces of peds; strongly acid (pH 5.4); gradual, smooth boundary.

B22t—26 to 36 inches light brownish-gray (2.5Y 6/2) heavy silty clay loam; few, medium, faint, gray to light-gray (5Y 6/1) mottles and few, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; firm; few tubular pores; color partly inherited from shale; few, weakly cemented, sandy shale fragments; few, yellowish-red (5YR 4/6) oxide stains; thin, discontinuous clay coatings on faces of peds and in pores; strongly acid (pH 5.3); gradual, smooth boundary.

R—36 to 60 inches, gray (5Y 5/1) shale and heavy silty clay loam; common, medium, prominent, brown and yellowish-brown (10YR 5/3 and 10YR 5/6) mottles and few, coarse, prominent, strong-brown (7.5YR 5/6 and 5/8) mottles; very weak, medium, platy structure due to the shale parent material; firm; color inherited partly from shale; thin, discontinuous, grainy coatings; common, weakly cemented, sandy shale fragments; slightly acid (pH 6.2).

The surface layer ranges from 5 to 10 inches in thickness. The subsurface layer is 3 to 8 inches thick and is very dark gray to grayish brown. In a few places these layers are underlain by shale and there is no subsoil. The subsoil ranges to 30 inches in thickness, ranges from brown to gray in color, and has a wide range in mottling or mixing of colors. The shale is generally a heavy silty clay loam, but layers range from medium silty clay loam to silty clay. Sand coats and sandy shale fragments are in the subsoil and substratum. This shale becomes very flaky when dry. The entire thickness of the shale ranges to many feet. Bands of reddish shale are in some areas near the boundary of soils that are upslope.

The Gosport soils differ from the Clanton soils in having formed in material weathered from gray and brown shale instead of reddish shale. Also, there are more sand grains intermingled with the shale in the Gosport soils.

Gosport silt loam, 14 to 18 percent slopes (GpE).—This soil is on irregular side slopes in wooded areas in the east-central part of the county. It is downslope and adjacent to the Gara and Lindley soils. This soil is upslope from the steep Gosport soils or very steep Clanton-Gosport silt loams.

This soil has the profile described as representative for the series.

Included with this soil in mapping were severely eroded areas where most of the surface layer is absent. Also included were small areas of the adjacent Gara and Lindley soils.

This soil is very erodible and is not suited to row crops, but some areas are managed with adjacent Gara and Lindley soils that are better suited to crops. Most of this soil is in woods and much of it is pastured. (Capability unit VIIe-2; woodland suitability group 9)

Gosport silt loam, 18 to 25 percent slopes (GpF).—This steep soil is on irregular side slopes on uplands in the east-central part of the county. It is downslope from the moderately steep Gosport soils and in some places is adjacent to and downslope from the strongly sloping or moderately steep Gara and Lindley soils. Some areas occupy the entire lower parts of the side slopes, but others are upslope from the very steep Clanton-Gosport silt loams.

In the profile of this soil, the surface layer is typically thinner than in the profile described as representative for the series.

Included with this soil in mapping were severely eroded areas and small areas of adjacent soils.

This soil is not suited to row crops, and it has very severe limitations for use as pasture. Most of the acreage is in woodland or woodland pasture. Clearing for pasture increases the hazard of erosion. (Capability unit VIIe-3; woodland suitability group 9)

Hixton Series

The Hixton series consists of shallow to moderately deep, light-colored, sandy and droughty soils of the uplands that formed in slightly weathered sandstone. These steep and very steep soils are on side slopes downslope from the Keswick or Lindley soils. Large areas are in the east-central part of the county west of the town of Hanley near Jones Creek. The native vegetation was trees.

In a representative profile, the surface layer is dark grayish-brown fine sandy loam about 8 inches thick. This is underlain by a brown fine sandy loam subsurface layer

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about 11 inches thick. When dry, the surface layer is light brownish gray and the subsurface layer is light gray. The subsoil is light olive-brown fine sandy loam. It contains more clay than the surface layer, is slightly firmer, and is about 14 inches thick. The substratum, at a depth of about 33 inches, is soft, stratified sandstone. It is slightly weathered and crushes to fine sandy loam.

The Hixton soils have low available water capacity and are moderately rapid in permeability. They are low to very low in organic-matter content and in available nitrogen, phosphorus, and potassium.

These soils are not suited to crops. They have severe limitations for pasture because of very steep slopes, low fertility, and droughtiness. If the soils are cleared of trees, runoff and erosion are excessive. Trees and other woody plants grow moderately well, because coarser roots can penetrate the soft parts of the sandstone and shading conserves moisture.

Representative profile of Hixton fine sandy loam, 20 to 40 percent slopes, 2,060 feet north and 410 feet west of the southeast corner of sec. 20, T. 75 N., R. 26 W., in a pasture on a north-facing upland slope of 25 percent:

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) and small areas of grayish-brown (10YR 5/2) fine sandy loam; light brownish gray (10YR 6/2) when dry; weak, medium, granular structure; friable; slightly acid (pH 6.2); clear, smooth boundary.

A2—8 to 19 inches, brown (10YR 5/3) fine sandy loam; light gray (10YR 7/2) when dry; weak, medium, platy structure, breaking to weak, medium, granular structure; friable; strongly acid (pH 5.4); clear, smooth boundary.

Bt—19 to 33 inches, light olive-brown (2.5Y 5/4) fine sandy loam; grainy coatings, light brownish gray (10YR 6/2) on ped faces; very weak, coarse, subangular blocky structure; friable, thin, discontinuous clay flows; few, dark oxide stains; medium acid (pH 5.6); gradual, smooth boundary.

C—33 to 48 inches, light olive-brown (2.5Y 5/4), soft, stratified sandstone that contains a few shale fragments; crushes to fine sandy loam; a few coarse root channels that are filled with silt and clay and that have dark organic coatings; strongly acid (pH 5.4).

The surface layer ranges from dark grayish brown to grayish brown in color and from 5 to 10 inches in thickness. The subsurface layer ranges from 8 to 12 inches in thickness and from brownish gray and brown to light gray in color. There is little range in texture in the surface layer, but some areas contain coarse silt. The subsoil ranges from 10 to 20 inches in thickness. It ranges to light loam in texture. Depth to the underlying sandstone ranges from 23 inches to about 42 inches. The upper part of the sandstone is soft, but the sandstone is harder with increasing depth. It contains small shale fragments. In some places this mixing of shale is quite common. The underlying sandstone ranges from 3 feet of mixed shale and sandstone to about 10 feet of pure sandstone. It is underlain by shale or limestone that ranges from olive brown to yellowish brown in color.

The Hixton soils as mapped in this county are coarser textured in the subsoil than is typical for the series.

Hixton fine sandy loam, 20 to 40 percent slopes (HxG).—This steep to very steep soil is on the upper part of side slopes below Keswick and Lindley soils and upslope from Clanton or Gosport soils.

Included with this soil in mapping were areas of steep and very steep Clanton, Gosport, and Lindley soils. Also included were some areas of sandstone outcrops.

This soil is used as woodland and for wildlife habitat, but it has severe limitations for pasture. It absorbs water readily, but rapid permeability and low available water capacity allow it to dry out very rapidly, and it tends to be droughty. This soil is very erodible where barren of vegetation. Droughtiness is the main limitation for woodland and wildlife habitat. (Capability unit VIIe-3; woodland suitability group 2)

Judson Series

The Judson series consists of deep, dark-colored, moderately well drained soils that formed in local alluvium washed from adjacent slopes. These soils are gently sloping on fan-shaped deposits at the foot of drainageways or on narrow foot slopes at the base of slopes. They are upslope from and adjacent to Zook and Kennebec soils. Judson soils are typically downslope from Ladoga and Sharpsburg soils. Slopes range from 2 to 6 percent. Judson soils are in small areas next to streams, mainly in the northern half of the county, but some very small areas are in other parts of the county. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black, very dark brown and very dark grayish-brown light silty clay loam about 28 inches thick. The subsoil is dark-brown and brown, friable silty clay loam. This layer extends to a depth of about 52 inches and contains a few, faint, grayish-brown and yellowish-brown mottles in the lower part. The substratum is dark yellowish brown and yellowish brown. It is similar in texture to the surface and subsoil layers. It is friable, light silty clay loam that is faintly mottled with grayish brown and light yellowish brown. The detailed profile that is given as representative for the series is not described to a depth great enough to show the substratum.

The Judson soils have high available water capacity and are moderate in permeability. Because they are gently sloping on foot slopes, there is considerable runoff from the adjacent upland slopes. Judson soils are high in organic-matter content, and they are slightly acid or neutral in the surface layer. They are low to medium in available nitrogen, low in available phosphorus, and medium to high in available potassium. There is a slight hazard of erosion because of water from the adjacent upland, but the thick surface layer absorbs moisture well. Because runoff is slow, deposition of silt from the adjacent uplands normally equals or exceeds the loss by erosion. In places siltation creates a greater problem than erosion.

Judson soils are used for crops. Most individual areas are small and are managed with the adjacent soils on bottom lands or on uplands. Judson soils are fertile and are easily kept in good tilth.

Representative profile of Judson silty clay loam, 2 to 6 percent slopes, 640 feet north and 300 feet west of the southeast corner of the NE¼ sec. 33, T. 77 N., R. 27 W., in a cultivated field on a slope of 4 percent:

Ap—0 to 9 inches, black (10YR 2/1) to very dark brown (10YR 2/2) light silty clay loam; very dark grayish brown (10YR 3/2) to very dark brown (10YR 2/2) when crushed; weak, medium, granular structure; friable; neutral; abrupt, smooth boundary.

A11—9 to 15 inches, very dark brown (10YR 2/2) light silty clay loam; very dark grayish brown (10YR 3/2) when crushed; weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A12—15 to 22 inches, very dark brown (10YR 2/2) light silty clay loam; moderate, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A3—22 to 28 inches, very dark grayish-brown (10YR 3/2) light silty clay loam; moderate, fine, subangular blocky structure; friable; many tubular pores; slightly acid; gradual, smooth boundary.

B2—28 to 35 inches, dark-brown (10YR 3/3) medium silty clay loam; faces of peds very dark grayish brown (10YR 3/2); moderate, medium, subangular blocky structure; friable; many tubular pores; neutral; gradual, smooth boundary.

B3—35 to 52 inches, brown (10YR 4/3) medium silty clay loam; few, fine, distinct, grayish-brown (10YR 5/2) mottles; weak, coarse, subangular blocky structure, to massive; friable; many tubular pores; very dark gray (10YR 3/1) coats on root channels.

The surface layer ranges from about 24 to 30 inches in thickness. In some areas the subsoil is thin and the substratum is mottled beginning at a depth of about 40 inches. This substratum in some areas is increasingly sandy with depth. The surface layer and subsoil range from silt loam to silty clay loam. Their combined thickness ranges from 30 to 52 inches. In some places very fine sand is mixed with the upper part of the surface layer.

The Judson soils differ from the Olmitz soils in having a silty surface layer and subsoil, whereas the Olmitz soils are loamy. Judson soils are not as gray or mottled in the subsoil as the Ely soils, and they are better drained. They have a thicker, dark-colored surface layer, lack a grayish subsurface layer, and are less acid than the Martinsburg soils.

Judson silty clay loam, 2 to 6 percent slopes (JuB).—This gently sloping soil is on fan-shaped deposits and in narrow bands at the base of slopes occupied by Ladoga or Sharpsburg soils. It is upslope from Kennebec or Zook soils. In a few areas it is upslope from Nevin and Wiota soils.

Included with this soil in mapping were small areas of Ely soils and small areas of other adjacent soils.

This soil receives runoff from the adjacent side slopes. Erosion and deposition are normally about equal. Control of erosion on side slopes above this soil reduces the amount of water that runs across this soil.

Most of the acreage is in crops. Individual areas are small, and they commonly are managed with adjacent soils. If erosion and runoff are controlled upslope, this soil is well suited to row crops. (Capability unit IIe-2; woodland suitability group 3)

Kennebec Series

The Kennebec series consists of deep, moderately dark colored, moderately well drained soils that formed in silty alluvium on first bottoms. These soils are near all the major streams and their tributaries in the county, in association with the Colo and Nodaway soils and Alluvial land. They are very close to the streams and are subject to some flooding. They are nearly level. The native vegetation was prairie grasses and in a few areas, scattered trees.

In a representative profile, the surface layer is silt loam about 40 inches thick. This layer is very dark gray in the upper part but grades to very dark grayish brown in the lower part. The substratum is friable silt loam that is dark grayish brown.

The Kennebec soils have high available water capacity. They are moderate in permeability. They are medium in organic-matter content, low in available nitrogen, and medium to high in available phosphorus and potassium. These soils are neutral to slightly acid throughout, and they have a deep, favorable root zone.

Kennebec soils are fertile and are used for crops. Their use is limited by flooding, but they dry out quickly after water recedes.

Representative profile of Kennebec silt loam, 50 feet west and 36 feet south of the northeast corner of the NW¼NE¼ sec. 2, T. 76 N., R. 27 W., in a cultivated field on a nearly level first bottom.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam; weak, medium, granular structure; friable; neutral (pH 7.0); clear, smooth boundary.

A11—7 to 12 inches, very dark gray (10YR 3/1) heavy silt loam; weak, fine, subangular blocky structure; friable; slight stratification present; neutral (pH 6.8); gradual, smooth boundary.

A12—12 to 28 inches, very dark gray (10YR 3/1) heavy silt loam; weak, fine to medium, subangular blocky structure; friable; neutral (pH 7.0); gradual, smooth boundary.

A13—28 to 40 inches, very dark grayish-brown (10YR 3/2) heavy silt loam; few, dark grayish-brown (10YR 4/2) strata present; weak, fine to medium, subangular blocky structure; friable; neutral (pH 7.0); gradual, smooth boundary.

C—40 to 52 inches, dark grayish-brown (10YR 4/2) heavy silt loam; massive; friable; neutral (pH 7.0).

The surface layer ranges from about 30 to 45 inches in thickness and from black to very dark grayish brown in color. It is typically silt loam. In places it contains some very fine sand. The substratum ranges from silt loam to light silty clay loam and from dark gray to very dark grayish brown. In some areas the content of fine sand in this layer increases with depth, especially at a depth between 40 and 60 inches.

Kennebec soils differ from the Nodaway soils because they are dark colored and are not stratified below the plow layer or upper 10 inches of the surface layer. They contain less clay than the Colo soils, they lack the mottling of those soils, and they are better drained. They contain less sand in the surface layer than the Spillville soils.

Kennebec silt loam (0 to 2 percent slopes) (Ke).—This nearly level soil is on first bottoms near all of the major streams and tributaries. It is adjacent to the Colo soils, which are farther away from the stream, and in some areas, it is adjacent to Nodaway soils and Alluvial land. Typically it is in positions adjacent to streams on the low first bottoms.

Included with this soil in mapping were small areas of the Colo, Nodaway, and Spillville soils. Also included were spots of sandy alluvium. The sandy and wetter areas are indicated on the soil map.

Individual areas of this soil are normally long and narrow, but there is a wide range in size and shape. Most large areas are row cropped along with adjacent soils. They are well suited to such use. Smaller areas on narrower bottoms are managed as cropland, pasture, or woodland with adjacent soils. Some small areas are being converted from woodland pasture to woodland.

The major limitation to use of this soil is flooding. In most years, however, flooding occurs early in spring before crops are planted. Floodwater does not stand for long periods. This soil dries out quickly and normally is in good tilth. On the narrow bottoms, floodwater leaves lighter colored coarse silt or fine sand deposits in some places. These deposits are normally thin and are mixed into the surface layer by cultivation. Generally, they are not harmful to tilth or crop production. (Capability unit I-3; woodland suitability group 10)

Keswick Series

The Keswick series consists of deep, light-colored, moderately well drained soils that formed in clayey, weathered glacial till on wooded uplands. These soils are on the upper part of side slopes and the sloping ends of ridges. Slopes are 9 to 14 percent. These soils are in the more densely wooded areas along the Middle and North Rivers and Jones and Clanton Creeks.

In a representative profile, the surface layer is very dark gray loam about 4 inches thick. The subsurface layer is dark grayish-brown, friable loam or silt loam about 5 inches thick. It is light brownish gray when dry. The subsoil is about 28 inches thick. The upper 5 inches is brown clay loam. The middle part is very firm, yellowish-red, strong-brown, and brown clay loam and clay mottled with yellowish red and grayish brown. The lower part is brown, firm light clay that has yellowish-brown mottles. The substratum, which begins at a depth of about 37 inches, is brown, firm clay loam mottled with yellowish brown and grayish brown. This layer contains carbonates or concretions of free lime.

The Keswick soils have high available water capacity and are slow in permeability. They are typically medium acid or strongly acid in the surface layer unless limed. Keswick soils are low in organic-matter content, low to very low in available nitrogen and phosphorus, and low to medium in available potassium. They have a deep root zone, but root formation is slowed by the clayey, slowly permeable subsoil.

Keswick soils are used as cropland but have severe limitations. They are not too sloping for tillage operations, but their use is limited by low fertility and the clay subsoil.

Representative profile of Keswick loam, 9 to 14 percent slopes, moderately eroded, 980 feet south and 1,840 feet west of the northeast corner of sec. 18, T. 74 N., R. 27 W., in a pasture on a side slope of 1 percent near the point of a ridge:

A1—0 to 4 inches, very dark gray (10YR 3/1) loam; weak, fine, granular structure; friable; slightly acid (pH 6.2); clear, smooth boundary.

A2—4 to 9 inches, dark grayish-brown (10YR 4/2) loam to silt loam; light brownish gray (10YR 6/2) when dry; weak, fine, platy structure, breaking to weak, fine, granular structure; friable; grainy coatings on ped faces; some very dark gray (10YR 3/1) coatings; medium acid (pH 5.8); clear, smooth boundary.

B1—9 to 14 inches, brown (7.5YR 4/4) clay loam; common, fine, reddish-brown (5YR 4/4) mottles; moderate, very fine, subangular blocky structure; firm; grainy coatings on ped faces; common pebbles; very strongly acid (pH 4.5); gradual, smooth boundary.

B21t—14 to 22 inches, yellowish-red (5YR 4/6) and strong-brown (7.5YR 4/6) clay; grayish-brown (10YR 5/2) mottles; moderate, medium, prismatic structure, breaking to moderate, medium, subangular blocky structure; very firm; thick, continuous clay films; extremely acid (pH 4.4); gradual, smooth boundary.

B22t—22 to 30 inches, brown (7.5YR 4/4) clay; many, fine, distinct, yellowish-brown (10YR 5/4 and 5/6) mottles and few, medium, yellowish-red (5YR 4/6) mottles; moderate, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; very firm, thick, continuous clay films; few pebbles; extremely acid (pH 4.4); gradual, smooth boundary.

B3t—30 to 37 inches, brown (10YR 5/3) light clay; common, medium, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm; thin, discontinuous clay films; few pebbles; very strongly acid (pH 4.8); gradual, smooth boundary.

C—37 to 60 inches, brown (10YR 5/3) clay loam; common, fine, grayish-brown (2.5YR 5/2) and few, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, prismatic structure, to massive; firm; common pebbles; carbonates at depth of 38 inches.

The surface layer ranges from 3 to 5 inches in thickness and from very dark gray to dark grayish brown in color. The subsurface layer is 4 to 7 inches thick and dark grayish brown to gray. Both layers are loam to silt loam. Where eroded, the subsurface layer or subsoil is exposed. The subsoil typically is light clay but grades to clay loam with depth. It is 18 to 36 inches thick and is brown, strong brown, grayish brown, and yellowish red. Mottles range from yellowish red to grayish brown. Depth to substratum ranges from 30 to 48 inches. Carbonates or lime concretions occur at a depth of 30 to 60 inches.

The Keswick soils differ from the Lamoni soils in having a lighter colored and thinner surface layer. They are not so gray in the upper part of the subsoil as the Lamoni soils, and they have a gray subsurface layer that the Lamoni soils do not have. Keswick soils have a more clayey, less permeable, and more mottled subsoil than the Lindley soils.

Keswick loam, 9 to 14 percent slopes, moderately eroded (KkD2).—This soil is on side slopes and on the ends of ridges in timbered uplands, downslope and adjacent to the Clinton soils and upslope from the moderately steep to very steep Lindley soils.

Included with this soil in mapping were small areas of Clinton and Lindley soils and very small areas that are severely eroded. The surface layer is dark grayish brown in some places.

This soil is poorly suited to row crops even if erosion is controlled. Some areas are suitable for management as cropland with the more suitable Clinton soils. Individual areas are all small. Most of the acreage is in pasture or wooded pasture and is managed with more sloping soils.

Soil tilth is poor in most places, and runoff is rapid. The major concern in management of this soil is erosion, but in some areas the slowly permeable clay subsoil causes seepage to occur along the contact with the Clinton soils. (Capability unit IVe–3; woodland suitability group 7)

Ladoga Series

The Ladoga series consists of deep, moderately dark colored, moderately well drained soils that formed in loess on uplands. These soils formed under prairie grass and forest vegetation. Ladoga soils are on ridgetops where slopes are 2 to 5 percent and on upper side slopes where slopes are 5 to 18 percent, in areas near major streams in all parts of the county.

The Ladoga soils are adjacent to both the Clinton and Sharpsburg soils on ridges and are upslope from the Lamoni and Gara soils. They also are on gently sloping high benches next to streams. In some areas they are on entire side slopes and merge with alluvial soils at the base of the slope.

In a representative profile, the surface layer is very dark gray silt loam about 7 inches thick. This is underlain by a dark grayish-brown silt loam subsurface layer, about 3 inches thick, that is light gray when dry. The subsoil is firm, dark-brown and brown silty clay loam about 37 inches thick. It has a few, strong-brown and grayish mottles below a depth of 24 inches, and its brown color is mixed with brownish gray below a depth of 35 inches. The substratum is friable, light brownish-gray and brown silty clay loam. This layer is less firm and compact than the subsoil. It is mottled with strong brown.

The Ladoga soils have high available water capacity and are moderately slow in permeability. Runoff is medium to rapid, depending on steepness of slope. Ladoga soils typically are medium acid to strongly acid in the surface layer unless limed, and they are medium in organic-matter content. They are low in available nitrogen and phosphorus and medium in available potassium. These soils have a deep, favorable root zone.

These soils are fertile and easily tilled, and they are suited to crops. Most areas are in crops, but some small areas are managed with the more sloping, adjacent soils as pasture or woodland. The major concern of management is control of erosion.

Representative profile of Ladoga silt loam, 5 to 9 percent slopes, 2,425 feet west and 1,560 feet north of the southeast corner, sec. 12, T. 75 N., R. 29 W., in a timbered pasture on a slope of 5 percent:

A1—0 to 7 inches, very dark gray (10YR 3/1) silt loam; moderate, medium, platy structure, breaking to moderate, thin, platy structure and weak, fine, granular structure; friable; neutral (pH 6.8); clear, smooth boundary.

A2—7 to 10 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, coarse to medium, platy structure, breaking to moderate, fine, subangular blocky structure; friable; nearly continuous, light-gray (10YR 7/2) grainy coatings when dry; abundant roots; strongly acid (pH 5.2); clear, smooth boundary.

B1—10 to 14 inches, dark-brown (10YR 3/3) silty clay loam; few, medium, faint, dark yellowish-brown (10YR 4/4) mottles; moderate, fine to very fine, angular and subangular blocky structure; friable; light-gray (10YR 7/2) grainy coatings when dry; many, fine, tubular pores; medium acid (pH 5.8); gradual, smooth boundary.

B21t—14 to 24 inches, brown (10YR 4/3) heavy silty clay loam; strong, fine, subangular blocky structure and some angular blocky structure; firm; common, fine, tubular pores; thin, discontinuous clay films; medium acid (pH 5.6); gradual, smooth boundary.

B22t—24 to 35 inches, brown (10YR 5/3) heavy silty clay loam; few, fine, faint, light brownish-gray (2.5Y 6/2) mottles and few, fine, distinct, strong-brown (7.5YR 5/6) mottles; moderate, fine, prismatic structure, breaking to moderate, medium to fine, subangular blocky structure; firm; thin, continuous clay films; few black oxides; few, fine, tubular pores; medium acid (pH 5.6); gradual, smooth boundary.

B3t—35 to 47 inches, mixed brown (10YR 4/3) and light brownish-gray (2.5Y 6/2) silty clay loam; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, coarse, subangular blocky structure; friable; few silt coatings; thin, discontinuous clay films; few, fine, tubular pores; common black oxides; relict, deoxidized, and leached weathering zone; medium acid (pH 5.6); gradual, smooth boundary.

C—47 to 60 inches, light brownish-gray (2.5Y 6/2) mixed with brown (10YR 4/3) silty clay loam; few, fine, distinct, strong-brown (7.5YR 5/6) mottles; massive, but some vertical cleavage; friable; few, fine, tubular pores; few black oxides; relict, deoxidized, and leached weathering zone; medium acid (pH 6.0).

Color of the surface layer varies widely; it ranges from nearly black to very dark grayish brown and very dark gray. In uneroded areas the surface layer is 5 to 8 inches thick, and the subsurface layer is 2 to 6 inches thick. In eroded areas where plowing has been deep, the light subsurface layer is mixed into the plow layer. As a result, the surface layer in cultivated areas appears light colored and gray when dry. Texture of this layer ranges from silt loam to light silty clay loam. In a few, very small areas along Grand River, the surface layer is fine sandy loam because it has been covered by local loess or fine, wind-deposited sand from nearby stream bottoms.

The brown subsoil ranges from 20 to 40 inches in thickness and from silty clay loam to light silty clay in texture. There is a wide range in the amount of mottling in the lower part of the subsoil. Here, colors range from strong brown or yellowish brown to light brownish gray.

The substratum is light brownish gray to olive gray and brown mixed and mottled with yellowish brown, brown, and strong brown. The loess, or wind-laid material, in which the Ladoga soils formed lies directly over glacial material. The loess commonly ranges from 12 to 15 feet in thickness, but it is only about 4 feet thick on side slopes adjacent to and upslope from soils formed in glacial material.

The Ladoga soils differ from Sharpsburg soils in having a thinner surface layer and a grayish subsurface layer. They have a darker and thicker surface layer than the Clinton soils, and their grayish subsurface layer is not so evident as that of the Clinton soils.

Ladoga silt loam, 2 to 5 percent slopes (LaB).—This gently sloping soil is on rounded ridgetops on the steeper ridges near the major streams. The ridges are typically narrow and are adjacent to broader areas of Sharpsburg soils farther away from the major stream.

This soil is upslope and adjacent to moderately sloping or strongly sloping Ladoga soils. In some areas it extends toward areas that are wooded and is adjacent to Clinton soils on the same ridgetop. On broader, level ridges it is downslope and adjacent to the Givin soils.

Included with this soil in mapping were small areas of moderately eroded Ladoga soils having similar slopes. Also included were small areas of other adjacent soils, as well as a few nearly level areas.

This soil is well suited to row crops if erosion is controlled, but it is in small areas and is managed with adjacent soils. There are few waterways, and runoff is medium. The soil is subject to erosion. (Capability unit IIe-1; woodland suitability group 3)

Ladoga silt loam, 2 to 5 percent slopes, moderately eroded (LaB2).—This soil occurs in the same positions in the landscape as the gently sloping, uneroded Ladoga soil. It has been more intensively farmed, and runoff has removed some of the original surface layer. About 5 inches of the original surface and subsurface layers remain.

The profile of this soil differs from the one described as representative for the series in having a very dark grayish-brown surface layer and in lacking a grayish subsurface layer in places. Plowing has mixed these layers with the upper part of the subsoil, and the present surface layer is grayish brown when dry.

Included with this soil in mapping were small areas of less eroded Ladoga soils. Small areas of Clinton soils also were included.

Most of this soil is in crops and is managed with adjacent soils. This soil is well suited to row crops if erosion is controlled. Runoff is somewhat more rapid on this soil than it is on Ladoga silt loam, 2 to 5 percent slopes. Consequently, controlling erosion is the major concern of management. This soil also is somewhat lower in available nitrogen and phosphorus. Where the subsoil is exposed, the plow layer has poor tilth and tends to dry out cloddy and hard. (Capability unit IIe-1; woodland suitability group 3)

Ladoga silt loam, 5 to 9 percent slopes (LaC).—This soil is on sharply rounded ridgetops and on the upper part of side slopes adjacent to and downslope from the gently sloping Ladoga soils. It is near all the major streams. This soil is upslope and adjacent to the Gara and Lamoni soils. In some areas it is upslope from the strongly sloping Ladoga soils. In a few areas near streams, it is on side slopes of high, loess-covered benches occupied by Givin soils or less sloping Ladoga soils upslope. Heads of side-slope drainageways extend into areas of this soil, and therefore many of the slopes are complex.

This soil has the profile described as representative for the series.

Included with this soil in mapping were very small areas of Ladoga soils that are more severely eroded or are gently sloping. Small areas of glacial till crop out in places, and those large enough to be significant in management are indicated on the soil map by a spot symbol.

This soil is moderately well suited to row crops. Most areas are in crops; small areas are in pasture. Some areas formerly in pasture are being converted to cropland. This soil is subject to erosion where it is used for crops. Small gullies form in waterways that are not protected. (Capability unit IIIe-1; woodland suitability group 3)

Ladoga silt loam, 5 to 9 percent slopes, moderately eroded (LaC2).—This soil is on high, rounded ridgetops and on narrow side slopes downslope from the gently sloping Ladoga soils. These ridges and short side slopes extend toward areas of Macksburg and Sharpsburg soils on broader divides between major streams. This soil is upslope from the steeper Gara and Lamoni soils. In some places it is upslope and adjacent to strongly sloping Ladoga soils.

Waterways extend into the narrow side slopes, and in these areas this soil has more irregular and more complex slopes than it has in areas that occupy entire ridgetops. A few small areas of this soil are on short side slopes of benches.

The combined surface and subsurface layers of this soil are only 3 to 7 inches thick. Plowing has mixed these layers with the upper part of the subsoil in some places. The plow layer generally is very dark grayish-brown silt loam but ranges to light silty clay loam.

Included with this soil in mapping were a few areas of soils that have a fine sandy loam surface layer and subsoil. These areas are near streams where the sandy material has been blown up from the stream valleys. These spots are indicated on the soil map by the spot symbol for sand. Also included were severely eroded areas where the subsoil is exposed. These are indicated on the soil map by the symbol for severely eroded spots. Very small areas of less sloping Ladoga soils and adjacent Gara soils also were included.

This soil is moderately well suited to crops. Most of it is now in cultivation, but some areas are managed with adjacent soils as pasture.

The major concern of management is controlling sheet erosion, but rapid runoff forms small gullies from where heads of drainageways extend into areas of this soil. In some areas tilth is poor, and the plow layer becomes cloddy if the brown subsoil is exposed. (Capability unit IIIe-1; woodland suitability group 3)

Ladoga silt loam, 9 to 14 percent slopes (LaD).—This strongly sloping soil is in small areas on side slopes in the wooded parts of the county, near all the major streams. Generally, it is downslope and adjacent to moderately sloping Ladoga soils on narrow ridges and upslope from the Gara soils. Slopes are complex and most areas have hillside drainageways.

In some places this soil is in bowl-shaped areas around the heads of branching drainageways. In these areas the soil is more sloping than it is on convex side slopes between drainageways. Some areas, especially those on the north side of streams, have long slopes that grade to loess-covered benches. A few areas are in high positions on foot slopes that form the side slopes of valleys below soils derived from bedrock, shale, or glacial till.

Included with this soil in mapping were many small areas of less sloping or more eroded Ladoga soils and the adjacent Gara soils. If these areas are significant to management, they are indicated on the map by the spot symbol for severely eroded spots or glacial till outcrops.

This soil is moderately well suited to row crops if erosion is controlled. Many areas, however, are managed with adjacent soils as pasture. A few areas remain wooded. Some areas that are large enough to be managed separately or that are adjacent to other soils now in crops are being converted to cropland. Controlling sheet and gully erosion is the major concern where this soil is in crops. (Capability unit IIIe-1; woodland suitability group 3)

Ladoga silt loam, 9 to 14 percent slopes, moderately eroded (LaD2).—This soil is along major streams in all parts of the county. It is in the same positions as Ladoga silt loam, 9 to 14 percent slopes.

This eroded Ladoga soil has only 3 to 7 inches of its original surface and subsurface layers remaining. Plowing has mixed the surface and subsurface layers with the upper part of the subsoil, and the present surface layer is very dark grayish brown. In places where the subsoil is exposed, the surface layer is browner than very dark grayish brown when moist and is gray when dry.

Included with this soil in mapping were areas that are severely eroded. Also included were areas of adjacent Gara soils. Where these areas are significant to management, they are indicated on the soil map by the symbol for severely eroded spots or glacial till spots. Other inclusions are a few small sandy spots that are indicated on the soil map by the spot symbol for sand.

Most of this soil is now in crops, but some areas are in pasture.

The major concern of management is controlling sheet erosion, but rapid runoff and concentration of water in drainageways cause serious gullying in places. Some areas have poor tilth and clods form easily where the subsoil is exposed. If erosion is controlled, this soil is moderately well suited to row crops. (Capability unit IIIe-1; woodland suitability group 3)

Ladoga silt loam, 14 to 18 percent slopes, moderately eroded (LaE2).—This moderately steep soil is in small areas on side slopes along major streams in the county. It has slopes that form bowllike areas below less sloping Clinton and Ladoga soils, and rounded, convex slopes adjacent to high stream benches. On many side slopes, it is adjacent to and upslope from the steep Gara and Lindley soils.

The profile of this soil differs from that described as representative for the series in having a surface layer that varies considerably in color and in thickness. In most places it is about 3 to 7 inches thick and very dark grayish brown.

Included with this soil in mapping were fairly large areas in which erosion has been severe and the brownish subsoil is exposed. In small areas glacial till is exposed. The till inclusions are more common in places where this soil is upslope from steep Gara and Lindley soils. Where the till and severely eroded areas are significant to management, they are indicated on the soil map by the symbol for severely eroded spots and for glacial till spots. Also included were several areas of moderately eroded and severely eroded Clinton soils.

This soil is poorly suited to row crops even if erosion is controlled. Most of the acreage is in pasture, but some areas adjacent to less sloping soils are managed with those soils as cropland. A few areas remain in woodland. If vegetative cover is removed, runoff is rapid and the soil is subject to very severe sheet erosion. Hillside waterways tend to gully quickly. The surface layer is generally in poor tilth. (Capability unit IVe-1; woodland suitability group 3)

Ladoga silt loam, benches, 2 to 5 percent slopes (LbB).—This soil is on loess-covered benches near the major streams. On larger benches it is downslope from and adjacent to the Givin soils on benches. On small, higher benches that have more sloping escarpments it is upslope from the more strongly sloping Caleb, Ladoga, and Mystic soils. In a few places it is adjacent to upland soils derived from till, shale, or loess.

This soil has a profile similar to that described as representative for the series, but it differs in position and in thickness of the loess. The loess ranges from 4 to 8 feet in thickness. The underlying material is stratified and is commonly sandy, but it ranges from silt loam to clay loam. There is a wider range in texture of the surface layer and subsoil than in Ladoga soils not on benches. Some areas contain fine sand in the profile.

Included with this soil in mapping were small areas of fine sandy loam blown up from nearby stream bottoms, and very small areas of the somewhat poorly drained Givin and Vesser soils. Where significant to management, areas of sand and of short, steep and very steep escarpments are shown on the soil map by spot symbols.

This soil is well suited to row crops if erosion is controlled. However, most areas are managed with adjacent soils. Some are in pasture and managed with the adjacent more sloping soils.

Although the hazard of erosion is only slight to moderate, it is the major concern in management. The soil is medium in organic-matter content, moderate in natural fertility, and in good tilth. (Capability unit IIe-1; woodland suitability group 3)

Lamoni Series

The Lamoni series consists of deep, dark-colored, somewhat poorly drained soils of the uplands that formed in weathered glacial till. Slopes are 5 to 14 percent. These soils are commonly in narrow bands downslope from the Clarinda, Clearfield, Ladoga, and Sharpsburg soils. The native vegetation was mainly prairie grasses, although a few areas had scattered trees. Lamoni soils are upslope from the Gara and Shelby soils and are in all parts of the county.

In a representative profile, the surface layer is black clay loam about 11 inches thick. The upper 6 inches of the subsoil is very dark grayish-brown clay loam. Below a depth of 17 inches, the subsoil is firm clay loam that extends to a depth of about 50 inches. The subsoil is dark grayish brown and grayish brown to a depth of 40 inches and light brownish gray below that depth. It is mottled with brown, yellowish brown, yellowish red, and strong brown. The substratum is light brownish-gray, firm clay loam mottled with strong brown. The mottles are larger in the substratum than in the subsoil.

The Lamoni soils have high available water capacity and are slow in permeability. They dry out slowly, and some areas are seepy and wet near the contact with more permeable soils upslope. Lamoni soils are medium acid in the surface layer unless limed, and they are medium to very low in organic-matter content. They are low in available nitrogen and phosphorus, and low to medium in available potassium.

Because of slope and slow permeability in the subsoil, runoff is rapid and erosion is a hazard. The less sloping soils are suited to crops, but limitations are severe. The more sloping soils are used for pasture.

Representative profile of Lamoni clay loam, 9 to 14 percent slopes, 100 feet south and 700 feet east of the northwest corner of sec. 36, T. 76 N., R. 29 W., in a small cemetery on a slope of 1 percent:

A1—0 to 11 inches, black (10YR 2/1) light clay loam; weak, fine, granular structure; friable; medium acid (pH 5.8); gradual, smooth boundary.

B1—11 to 17 inches, very dark grayish-brown (10YR 3/2) light clay loam; dark grayish brown (10YR 4/2) when crushed; moderate, very fine, subangular blocky structure; friable; medium acid (pH 5.8); gradual, smooth boundary.

IIB21t—17 to 23 inches, dark grayish-brown (10YR 4/2) medium clay loam; common, fine, faint, brown (7.5YR 5/4) mottles; moderate, fine and very fine, subangular blocky structure; firm; thin, discontinuous clay films; medium acid (pH 5.8); gradual, smooth boundary.

IIB22t—23 to 32 inches, grayish-brown (10YR 5/2) heavy clay loam; many, fine, distinct, brown (7.5YR 5/4) mottles; moderate, fine, subangular blocky structure; firm; nearly continuous clay films; few pebbles; slightly acid (pH 6.2); gradual, smooth boundary.

IIB23t—32 to 40 inches, grayish-brown (10YR 5/2) and light brownish-gray (10YR 6/2) heavy clay loam; common, medium, distinct, yellowish-red (5YR 5/6) mottles and few, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine, subangular blocky structure; firm; nearly continuous clay films; few pebbles; slightly acid (pH 6.2); gradual, smooth boundary.

IIB3t—40 to 50 inches, light brownish-gray (10YR 6/2) clay loam; many, fine and medium, distinct, strong-brown (7.5YR 5/6) mottles; weak, medium, prismatic structure, breaking to weak, fine, subangular blocky structure; firm; thin, discontinuous clay films; common pebbles; slightly acid (pH 6.4); gradual, smooth boundary.

C—50 to 60 inches, light brownish-gray (10YR 6/2) clay loam; many coarse, distinct, strong-brown (7.5YR 5/6) mottles; weak, prismatic structure, to massive; firm; common pebbles; slightly acid (pH 6.4).

The surface layer, where uneroded, ranges from 10 to 14 inches in thickness and is very dark gray to black in color. Where this layer approaches its maximum thickness, it is darker colored and more silty than in places where it is thinner. The subsoil is 20 to 40 inches thick and is exposed in some places on rounded ridges that are severely eroded. The subsoil between depths of about 24 and 40 inches, ranges from heavy clay loam to clay. In steeper areas near the major streams, the lower part of the subsoil and the substratum are browner in color than in other areas, and lime is at a shallower depth than in the representative profile. Some areas, especially those in the southeastern part of the county, have a dark grayish-brown subsoil that contains many strong-brown mottles and some reddish mottles. The substratum ranges from light brownish gray to light olive gray or gray and has a wide range in size of yellowish-brown and strong-brown mottles.

In mapping unit LcD3, the surface layer is thinner and lighter colored than has been defined as the range for the series. The Lamoni soils are better drained than the Clarinda soils and do not have the thick, gray, plastic clayey subsoil of those soils. Lamoni soils do not have the grayish subsurface layer that is present in the Keswick soils, and in uneroded areas they typically have a thicker surface layer.

Lamoni clay loam, 5 to 9 percent slopes (LcC).—This soil is on short side slopes and on slopes that form bowllike areas at the heads of upland drainageways. It is downslope from the Nira, Clarinda, Clearfield, and Sharpsburg soils. Except on very short slopes, it is commonly upslope from the steeper Shelby soils.

The profile of this soil is similar to that described as representative for the series, but it typically is more silty in the surface layer and, in many areas, contains more gray mottling in the subsoil.

Individual areas of this soil are small, and small areas of the Clarinda and Clearfield soils were included in mapping. Also included are similar areas that have a more reddish upper part of the subsoil.

This soil dries out slowly and causes seepy areas in the more permeable soils upslope. It is moderately suited to row crops if erosion is controlled and seepy spots are drained. Interceptor tile drains are helpful, and regular tiling works well in some areas.

Most of this soil is in permanent pasture, but some areas are now cultivated and are managed with adjacent soils. The major limitation when in pasture is seepage. If the soil is cultivated, the surface layer becomes sticky when wet and hard and cloddy when dry, even though the organic-matter content is fairly high. (Capability unit IIIe–3; woodland suitability group 9)

Lamoni clay loam, 5 to 9 percent slopes, moderately eroded (LcC2).—This soil is on short side slopes and on slopes that form bowllike areas around the heads of drainageways. It is downslope from the Clarinda and Sharpsburg soils and upslope from steeper Gara and Shelby soils.

The profile of this soil has a thinner surface layer than the one described as representative for the series. This layer averages 4 to 8 inches in thickness and is very dark grayish-brown clay loam.

Included with this soil in mapping were small areas of Clarinda soils. Small severely eroded spots also were included, and they are shown on the soil map by the symbol for severely eroded spots. Also included were a few small areas of a soil that has a thinner, strong-brown heavy clay loam or clay subsoil containing reddish mottles.

Individual areas of this Lamoni soil range from 5 to 15 acres in size. Most of the acreage is in cultivation and managed with adjacent soils.

This soil is moderately suited to row crops if erosion and seepy spots are controlled. Because the soil is somewhat poorly drained and tends to become saturated with water, it dries out very slowly. The surface layer tends to be sticky when wet and commonly is hard and cloddy when dry. A seepy band normally occurs in the area just above this soil. In most places it is practical to install interceptor tile drains in the more permeable soils upslope. (Capability unit IIIe–3; woodland suitability group 9)

Lamoni clay loam, 9 to 14 percent slopes (LcD).—This soil is mostly at the heads of drainageways and on short side slopes. In some areas it is on short, rounded shoulders of slopes or on the crests of ridges. It is downslope from the Ladoga and Sharpsburg soils and upslope from steeper Gara and Shelby soils. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Clarinda and Clearfield soils. Also included were small areas of Shelby soils.

Individual areas of this soil range from 5 to 25 acres in size. Most of the acreage is managed with adjacent soils as pasture. This soil is poorly suited to row crops, even if erosion and seepy spots are controlled. Narrow bands of seepage occur at the boundaries of the soils that are upslope. Interceptor tile drains in soils upslope are helpful in some areas. (Capability unit IVe–2; woodland suitability group 9)

Lamoni clay loam, 9 to 14 percent slopes, moderately eroded (LcD2).—This is the most extensive Lamoni soil in the county. It is on short, rounded slopes along waterways and around heads of coves or bowllike areas. This soil is downslope from the Ladoga and Sharpsburg soils and upslope from moderately steep Gara and Shelby soils. Some of these coves contain short branching drainageways.

The profile of this soil has a thinner surface layer than the one described as representative for the series. The very dark grayish-brown surface layer ranges from 3 to 8 inches in thickness. It is medium clay loam, and it is firm and compact in spots where the surface layer and some of the subsoil have been mixed by plowing.

Included with this soil in mapping were small areas of Clarinda soils, which are indicated on the soil map by the symbol for clay spot. Also included were very small areas of severely eroded Lamoni soils. These are indicated on the soil map by the symbol for severely eroded spots. Also included were small areas of a soil that has a thinner, brown or strong-brown clay or heavy clay loam subsoil that has reddish mottles.

Individual areas of this Lamoni soil range from 5 to 25 acres in size. Much of the acreage is cultivated, but the soil is poorly suited to row crops, even if erosion and seepy spots are controlled. The soil is suited to pasture, but most areas are managed with adjacent soils that are better suited to row crops. Areas used for pasture are mainly in small areas that are upslope from steeper Gara or Shelby soils. Interceptor tile drains in the more permeable soils upslope reduce seepage. (Capability unit IVe–2; woodland suitability group 9)

Lamoni clay loam, 9 to 14 percent slopes, severely eroded (LcD3).—This soil occurs in very small areas. It is on side slopes, downslope from the Ladoga and Sharpsburg soils. It typically is adjacent to or within larger areas of less eroded Lamoni or Shelby soils.

The profile of this soil differs from the one described as representative for the series in having only 1 to 3 inches of the original surface layer remaining. The present surface layer is about 7 inches thick and contains material brought up from the upper part of the subsoil by plowing. This layer is commonly dark-brown clay loam and in poor tilth. The subsoil and underlying layers of this soil are similar to those described as representative for the series.

Included with this soil in mapping were small spots of severely eroded Shelby soils. Also included were small areas of Clarinda soils near the upper boundaries, as well as small areas of a soil that has a thinner, strong-brown clay or clay loam subsoil having reddish mottles.

This Lamoni soil is not suited to row crops, and some of the acreage has been converted to pasture. With good management, grasses and legumes can be established. Because the soil is in very small areas, some areas are managed with adjacent soils that are more suitable for crops.

Permeability is very slow. Runoff is very rapid, and erosion is a very severe hazard. Gullies form readily, and the entire surface layer is in very poor tilth and cloddy. (Capability unit VIe–2; woodland suitability group 9)

Lindley Series

The Lindley series consists of deep, light-colored, moderately well drained soils of the uplands that formed in weathered clay loam glacial till under trees. These soils are on ridges and side slopes. Slopes range from 9 to 40 percent but, in most places, are 15 percent or more. Lindley soils are downslope from narrow ridges occupied by Clinton soils or the till-derived Keswick soils. They are mainly upslope from Clanton, Gosport, and Nordness soils, but they extend to the narrow bottom lands in places.

Individual tracts of Lindley soils are large and are in the steeper, more densely timbered areas along North River, Middle River, and Clanton Creek. In addition, there are small areas along Grand River. The vegetation is predominantly oak trees.

In a representative profile, the surface layer is very dark gray loam about 5 inches thick. This is underlain by a grayish-brown subsurface layer of friable loam about 4 inches thick. The subsoil is clay loam about 25 inches thick. This layer is mainly brown and yellowish brown, but in the lower part it is mixed with grayish brown and mottled with yellowish brown. It is mostly firm in consistence. The substratum is yellowish-brown and grayish-brown, firm clay loam that is mottled with yellowish brown. Free lime or carbonates occur at a depth of about 40 inches.

The Lindley soils have high available water capacity and are moderately slow in permeability. They are very low in available nitrogen, very low in available phosphorus, and low in available potassium. They are medium to strongly acid and low to very low in organic-matter content.

The less sloping Lindley soils have limited use as cropland. The steeper areas are in timber.

Representative soil profile of Lindley loam, 25 to 40 percent slopes, 400 feet north and 620 feet west of the southeast corner of the NW¼ sec. 17, T. 74 N., R. 27 W., on a north-facing slope of 30 percent:

A1—0 to 5 inches, very dark gray (10YR 3/1) loam; grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; strongly acid (pH 5.5); clear, smooth boundary.

A2—5 to 9 inches, grayish-brown (10YR 5/2) loam; pale brown (10YR 6/3) when dry; weak, fine, platy structure breaking to weak, very fine, subangular blocky structure; friable; common sand and silt grains on ped faces; very strongly acid (pH 4.7); clear, smooth boundary.

B1—9 to 14 inches, brown (10YR 5/3) light clay loam; moderate, fine and very fine, subangular blocky structure; friable; abundant sand and silt grains on ped faces; very strongly acid (pH 4.7); clear, smooth boundary.

B21t—14 to 20 inches, yellowish-brown (10YR 5/4) heavy clay loam; moderate, fine, angular and subangular blocky structure; firm; thin, continuous clay films; common pebbles; very strongly acid (pH 4.7); gradual, smooth boundary.

B22t—20 to 29 inches, yellowish-brown (10YR 5/4) heavy clay loam; common, fine, distinct, grayish-brown (10YR 5/2) mottles and a few, fine, faint, yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure breaking to moderate, fine, subangular blocky structure; firm; medium, continuous clay films; common pebbles; very strongly acid (pH 4.6); gradual, smooth boundary.

B3t—29 to 34 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) clay loam; few, fine, faint, yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure breaking to moderate, medium, angular blocky structure; firm; few sand and silt grains on ped faces; thin, continuous clay films; common pebbles; slightly acid (pH 6.1); clear, smooth boundary.

C—34 to 60 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (10YR 5/2) clay loam; common, fine, faint, yellowish-brown (10YR 5/6 and 5/8) mottles; weak, medium, prismatic structure breaking to weak, medium, angular blocky structure; firm; common pebbles; carbonates at depth of 40 inches; mildly alkaline (pH 7.8).

There is a wide range in color of the surface layer. In timbered areas there is a thin, black, organic layer of leaf duff 1 or 2 inches thick. In pasture areas this duff is absent, and the thin surface layer is very dark gray to very dark grayish brown. In some places erosion has removed the original surface layer, and this has exposed the subsurface layer or, in small areas, the subsoil. In eroded or cultivated areas, the present surface layer is grayish brown or brown.

The subsoil ranges from 24 to 40 inches in thickness. The middle part of it is brown to yellowish-brown, firm medium clay loam to heavy clay loam. The amount and size of grayish-brown and yellowish-brown mottles vary widely, but mottles normally are present. The substratum ranges from grayish-brown to yellowish-brown. Free lime or carbonates generally are in the substratum at a depth of 36 to 50 inches. In a few areas the carbonates or free lime are leached to greater depths.

The Lindley soils differ from Shelby soils in having a thinner surface layer and a distinct grayish-brown subsurface layer. Lindley soils are similar to the Gara soils in many respects, but they have a thinner surface layer, have a more evident, lighter colored subsurface layer, and normally are more acid throughout than the Gara soils.

Lindley loam, 9 to 14 percent slopes, moderately eroded (LdD2).—This strongly sloping soil is on side slopes that border narrow ridges occupied by Clinton soils. It is upslope from steeper Lindley soils or Clanton or Gosport soils.

The profile of this soil is similar to that described as representative for the series, but it is more variable in thickness and color of the surface layer. Most of the original cover of trees has been removed, and only 2 or 3 inches of the original surface layer remains. In cultivated areas the subsurface layer has been mixed with the thin surface layer, and the plow layer is grayish brown or brown.

Included in mapping were very small areas of the Keswick soils and small areas that are severely eroded and have the subsoil exposed. If these eroded areas are significant, they are indicated on the soil map by the symbol for severely eroded spots. In places where this soil is above soils derived from limestone or shale, small bands of those materials were included in mapping, and the bands that are important to management are indicated on the soil map by a symbol for rock outcrop or shale.

Even if erosion is controlled and fertility is improved, this soil is poorly suited to row crops. Runoff is rapid, and erosion is a serious hazard. The organic-matter content is low, and where the subsoil is exposed, tilth is poor. (Capability unit IVe–3; woodland suitability group 4)

Lindley loam, 14 to 18 percent slopes, moderately eroded (LdE2).—This moderately steep soil is on irregular side slopes in timbered areas. It is adjacent to and downslope from moderately sloping Clinton soils. Near the ends or points of ridges occupied by Clinton soils, this soil is downslope from the strongly sloping Keswick soils. It is normally upslope from steeper Lindley soils or Clanton, Gosport, or Nordness soils. It commonly is in narrow, irregular bands that form the sides of valleys.

The profile of this soil is similar to that described as representative for the series, but it varies more widely in color and thickness of the surface layer. Moderate erosion has removed part of the original surface layer, and the organic-matter content has been reduced. Consequently, the present surface layer consists of material from both the original surface and subsurface layers, and it averages 3 to 6 inches in thickness. It is commonly dark grayish brown or grayish brown.

Included with this soil in mapping were small areas of adjacent soils and areas that are more severely eroded. Significant areas of severe erosion are indicated on the soil map by the symbol for severely eroded spots. Where this soil is upslope from shale- and limestone-derived soils, small areas of these materials also were included. Areas of these included materials that are important to management also are indicated on the soil map by spot symbols.

This soil is not suited to row crops, because of steepness of slope and the severe hazard of erosion. The organic-matter content is very low. Areas on side slopes contain drainageways that are easily gullied. At one time, much of the original timber was cleared and some areas were cultivated. Most areas have been converted to pasture, and some now are in second-growth timber. (Capability unit VIe–2; woodland suitability group 4)

Lindley loam, 18 to 25 percent slopes (LdF).—This steep soil is on side slopes in wooded areas along major streams and tributaries. It is downslope from less steep Lindley soils. It commonly occupies the entire hillside with soils on bottom lands downslope. However, some areas in Clanton or Gosport soils are downslope. Along the Middle and North Rivers, there are some areas adjacent to and upslope from limestone.

Nearly all the acreage of this soil is in woods, and a black organic (leaf duff) layer is commonly present. This layer is only 1 to 2 inches thick and is underlain by the very dark gray loam surface layer. This soil has a thinner subsoil and contains free lime or carbonates closer to the surface than the less steep Lindley soils.

Included with this soil in mapping were small, severely eroded areas and small areas of shale or limestone outcrops. These areas are indicated on the soil map by spot symbols for severe erosion and outcrops of shale or limestone.

This soil is suited to woodland and wildlife habitat. Most areas are in woodland pasture but furnish limited forage for livestock. Owing to the tree cover, gullying is less serious than in cleared areas. However, this soil contains large, stabilized ravines.

Some areas presently in pasture can be made more productive by renovating them, but operating farm machinery is hazardous because of steep slopes, gullies, and the generally rough terrain. (Capability unit VIIe–1; woodland suitability group 5 or 6)

Lindley loam, 25 to 40 percent slopes (LdG).—This very steep Lindley soil is on side slopes near major streams in wooded areas. It is adjacent to and downslope from less steep Lindley soils. In some areas it occupies the entire hillside. Where it extends to the stream bottom, it is adjacent to the Nodaway soils or Alluvial land.

This soil is almost entirely covered by hardwood timber, and oak is the dominant species. The total acreage is small, but some locally important areas occur. The soil contains more large stabilized ravines than do less steep Lindley soils.

The profile of this soil is the one described as representative for the series. Larger areas of soils derived from shale were included in mapping this soil than in mapping other Lindley soils.

Runoff is excessive, fertility is low, and gullying is a problem. Pastures are unproductive. Farm equipment cannot be used safely on this soil, and consequently pastures are difficult to renovate. This soil is better suited to woodland and wildlife habitat than to crops and pasture. (Capability unit VIIe–1; woodland suitability group 5 or 6)

Lindley soils, 14 to 18 percent slopes, severely eroded (LeE3).—These moderately steep soils are on irregular side slopes. They are adjacent to and downslope from moderately sloping Clinton soils. Near the ends of points of the ridges, they are downslope from the strongly sloping Keswick soils. They are commonly upslope from steeper Lindley soils, or Clanton, Gosport, or Nordness soils. Most individual areas are not large.

The surface layer of these soils ordinarily is dark grayish brown or brown and consists mainly of the subsurface layer and some of the subsoil. Most of the original surface layer has been eroded away.

Included with this soil in mapping were small areas of adjacent soils.

Although many areas have been cultivated in the past, these soils are not suited to row crops, because of steep slopes and severe erosion. Many areas have been converted to pasture, and some are in woods. Soil tilth generally is poor, which makes establishment of new stands of grasses more difficult. Tree growth is slow.

The organic-matter content is very low, and the surface layer absorbs water slowly. Runoff is rapid, and the hazard of further erosion and gullying is very severe. (Capability unit VIe–2; woodland suitability group 4)

Macksburg Series

The Macksburg series consists of deep, dark-colored, somewhat poorly drained soils of the uplands that formed in loess. These soils are on broad, nearly level divides between the major streams and on gentle side slopes adjacent to the broad divides. Slopes range from 0 to 5 percent.

The Macksburg soils are adjacent to and upslope from the more sloping and better drained Sharpsburg soils. On broader ridgetops they are on or near the slope break and adjacent to the nearly level, poorly drained Winterset soils. Where the broad divides extend into wooded areas, these soils are adjacent to the Givin soils. The native vegetation was prairie grasses.

In a representative profile, the surface layer is silty clay loam about 18 inches thick. This layer is mainly black, but it grades to very dark brown in the lower part. The subsoil, between depths of 18 and 24 inches, is very dark grayish-brown, friable silty clay loam. Below 24 inches, the subsoil is firm, dark grayish-brown grading to grayish-brown heavy silty clay loam that extends to a depth of about 62 inches. It is light silty clay loam in the lower part. The subsoil is mottled with yellowish brown, olive gray, and brown. The substratum is grayish-brown or olive-gray silty clay loam that is highly mottled with yellowish brown, brown, and strong brown. It is less firm than the subsoil. The detailed profile that is given as representative for the series is not described to a depth great enough to show the substratum.

The Macksburg soils have high available water capacity and are moderately slow in permeability. They are low to medium in available nitrogen and phosphorus and medium to high in available potassium. They are high in organic-matter content and medium to strongly acid in the surface layer unless limed.

These soils have a favorable root zone. Nearly all areas of the Macksburg soils are in crops. Their limitations to use for crops are only slight.

Representative profile of Macksburg silty clay loam, 0 to 2 percent slopes, 783 feet west and 390 feet north of the southeast corner of sec. 31, T. 76 N., R. 28 W., in a cultivated field:

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, fine and medium, subangular blocky structure; firm; few worm casts; slightly acid (pH 6.3); abrupt, smooth boundary.

A1—6 to 12 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, fine, subangular blocky structure, breaking to moderate, fine, granular structure; friable; few, fine, inped tubular pores; very dark gray (10YR 3/1) worm casts; strongly acid (pH 5.2); gradual, smooth boundary.

A3—12 to 18 inches, black (10YR 2/1) and very dark brown (10YR 2/2) silty clay loam; moderate, very fine, subangular blocky structure and moderate, fine, granular structure; friable; few, fine and medium, inped tubular pores; few, fine, hard concretions of an oxide; few, very dark grayish-brown (10YR 3/2) worm casts; strongly acid (pH 5.3); gradual, smooth boundary.

B1—18 to 24 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) silty clay loam; faces of peds very dark gray (10YR 3/1); very fine, subangular blocky structure and some moderate, fine, granular structure; friable; common, fine, inped tubular pores; few, fine, hard oxides; strongly acid (pH 5.1); gradual, smooth boundary.

B21t—24 to 30 inches, dark grayish-brown (10YR 4/2) and brown (10YR 5/3) heavy silty clay loam; few, fine, faint, brown (10YR 5/3) mottles; moderate, fine, subangular blocky structure; firm; common, fine, inped tubular pores; thin, discontinuous clay films; common, fine, hard oxides and few, fine, soft oxides; strongly acid (pH 5.1); gradual, smooth boundary.

B22t—30 to 42 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) and light brownish-gray (2.5Y 6/2) heavy silty clay loam; faces of peds grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4); few to common, fine, distinct, yellowish-brown (10YR 5/6 and 5/4) mottles; weak, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; firm; many, fine, inped tubular pores; thin, discontinuous clay films; common, fine, hard oxides; relict, deoxidized, and leached weathering zone; strongly acid (pH 5.4); gradual, smooth boundary.

B3—42 to 62 inches, grayish-brown (2.5Y 5/2) and gray (10YR 5/1 to 5Y 5/1) light silty clay loam; common to many, fine, distinct, yellowish-brown (10YR 5/6) mottles; few, fine, distinct, dark-brown (7.5YR 3/2) and light olive-gray (5Y 6/2) mottles; few, fine, distinct segregations of strong brown (7.5YR 5/8); weak, medium, prismatic structure; firm; common, fine, inped tubular pores; common, fine, soft and hard oxides; relict, deoxidized, and leached weathering zone; medium acid (pH 6.0); gradual, smooth boundary.

The dark surface layer ranges from 14 to 20 inches in thickness and from very dark gray to black in color. On narrow divides and gentle slopes, the upper 4 to 7 inches of the subsoil is normally free of mottling. In more nearly level areas, the entire subsoil is mottled with brown and gray. Size and degree of mottles increase with depth. The subsoil ranges from 24 to 50 inches or more in thickness and is medium silty clay loam to light silty clay loam in most of the layer. The gray, mottled substratum typically occurs at a depth of about 3 to 6 feet. It is less firm and less clayey than the subsoil and has a wide range in the size and abundance of brown mottles.

The Macksburg soils differ from the Winterset soils in being better drained and having a more permeable, browner subsoil. Macksburg soils have a thicker surface layer and a mottled, less brown subsoil than the Sharpsburg soils, and they are more poorly drained.

Macksburg silty clay loam, 0 to 2 percent slopes (MbA).—This nearly level soil is on divides between the major streams. In some areas it is on the entire ridgetop of narrow divides. On broad ridges it is on the outer borders near the slope break and is adjacent to the Winterset soils. It is upslope from and adjacent to the gently sloping Macksburg and Sharpsburg soils. Where divides extend toward more strongly sloping, wooded areas, it is adjacent to the Givin soils on the same ridgetops.

This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of the Sperry and Winterset soils. Also included, in the southeastern part of the county, were 2,400 acres of a soil that has a higher content of clay in the subsoil than this soil.

This soil is well suited to row crops. Some areas are large enough to be managed separately, but most are managed with the adjacent soils. There is little runoff of surface water. Some areas dry out slowly and require tile drainage. (Capability unit I-2; woodland suitability group 8)

Macksburg silty clay loam, 2 to 5 percent slopes (MbB).—This gently sloping soil is on the borders of broad level divides between major streams. It is upslope from and adjacent to the moderately sloping Sharpsburg soils and downslope from the nearly level Macksburg and Winterset soils.

Included with this soil in mapping were about 3,700 acres in the southeastern part of the county in which the soil has a higher content of clay in the subsoil than this soil. The heads of drainageways extend into areas of this soil, and small areas of poorly drained Colo soils along drainageways also were included. Also included were small areas of the gently sloping Sharpsburg soils.

This soil is well suited to row crops if erosion is controlled. The soil occurs in irregularly shaped areas, and it is managed with adjacent soils. There are a few drainageways, and runoff is medium. (Capability unit IIe-1; woodland suitability group 8)

Martinsburg Series

The Martinsburg series consists of deep, light-colored soils that formed in alluvial material washed down from adjacent loess-covered side slopes. These soils are moderately well drained to well drained. They are on narrow foot slopes at the base of Clinton soils on side slopes. They are upslope from and adjacent to the Nodaway soils. Slopes range from 2 to 5 percent. Martinsburg soils are in small, narrow areas next to streams in the wooded areas of the county. They are most common in the central and east-central parts of the county. The native vegetation was trees.

In a representative profile, the surface layer is dark grayish-brown silt loam about 8 inches thick. The subsurface layer is dark grayish-brown silt loam in the upper 9 inches and brown light silty clay loam in the lower 6 inches. The subsoil is brown, firm silty clay loam about 27 inches thick. It contains some sand grains. The substratum, at a depth of about 50 inches, is dark yellowish-brown or yellowish-brown light silty clay loam that has light brownish-gray mottling. It contains fine sand and shows evidence of stratification. The detailed profile described as representative for the series is not described to a depth great enough to show the substratum.

The Martinsburg soils have high available water capacity and are moderate in permeability. They are strongly acid in the subsoil but range from neutral to strongly acid in the surface layer. They are low in organic-matter content, low in available nitrogen and phosphorus, and medium in available potassium. These soils have a deep, very favorable root zone.

Martinsburg soils are suited to row crops if protected from erosion and siltation. Many areas are too small to be managed separately from the adjacent soils. The major limitation is runoff from adjoining slopes, and some erosion is evident. Erosion is only slight and is nearly balanced by deposition on the more gentle slopes. These soils contain waterways that gully easily when runoff from higher areas is excessive.

Representative profile of Martinsburg silt loam, 2 to 5 percent slopes, 1,720 feet north and 1,420 feet east of the southwest corner of sec. 17, T. 75 N., R. 28 W., in a cultivated field on an east-facing slope of 3 percent, west of stream:

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam; weak, fine, granular structure; friable; neutral (pH 6.6); clear, smooth boundary.

A21—8 to 17 inches, dark grayish-brown (10YR 4/2) silt loam; grayish-brown (10YR 5/2) coatings on ped faces; weak, very fine, subangular blocky structure; friable; neutral (pH 6.8); clear, smooth boundary.

A22—17 to 23 inches, brown (10YR 4/3) light silty clay loam; faces of peds dark grayish brown (10YR 4/2); weak to moderate, fine and medium, subangular blocky structure; friable; strongly acid (pH 5.5); gradual, smooth boundary.

B2t—23 to 38 inches, brown (10YR 4/3) medium silty clay loam; faces of peds dark grayish brown (10YR 4/2); moderate, medium, prismatic structure; firm; thin, continuous clay films; few sand grains; strongly acid (pH 5.4); gradual, smooth boundary.

B3t—38 to 50 inches, brown (10YR 4/3) medium silty clay loam; faces of peds dark brown (10YR 3/3); weak, medium to coarse, subangular blocky structure; firm; thin, discontinuous clay flows; strongly acid (pH 5.4).

The surface layer generally ranges from 6 to 9 inches in thickness and from dark gray to grayish brown in color. This layer receives recent deposition from adjacent side slopes and, in places, ranges up to 15 inches in thickness. This recent deposition is normally dark grayish brown and is fine sandy loam or silt loam to loam. The subsurface layer is 12 to 20 inches thick. The combined thickness of the surface layer and subsurface layer ranges from 18 to 26 inches. The subsoil is light to medium silty clay loam that is 20 to 48 inches thick, is brown to yellowish brown, and contains little mottling. The substratum occurs at a depth of 48 to 70 inches and has a wide range in texture because of stratification of the alluvial material.

The Martinsburg soils differ from Judson soils in being lighter colored and having a grayish subsurface layer. They do not have as thick or as dark a surface layer as the Vesser soils, and they are not so mottled and gray in the subsoil. Martinsburg soils are better drained than the Vesser soils.

Martinsburg silt loam, 2 to 5 percent slopes (MgB).—This light-colored gently sloping soil is on fans and also occurs in bands on narrow foot slopes at the base of side slopes in wooded areas. These adjacent side slopes are mainly occupied by the Clinton soils. This soil is upslope from and adjacent to Nodaway soils, which are on first bottoms. It is in small, narrow areas. It is minor in total extent but is an important soil along streams in wooded areas.

Included with this soil in mapping were small areas of steeper Martinsburg soils. Also included were small areas of Nodaway soils and some areas of the Nodaway-Martinsburg complex.

This soil is subject to runoff from the adjacent side slopes, and erosion is a hazard in some areas. Some areas contain drainageways that gully easily. Erosion and deposition from side slopes are commonly about equal, but in some places deposition from eroded slopes is a greater hazard than erosion.

Areas of this soil are small and are managed with other soils as cropland or pasture. This soil is well suited to row crops if erosion and siltation are controlled. (Capability unit IIe-2; woodland suitability group 3)

Mystic Series

The Mystic series consists of deep, moderately dark colored, somewhat poorly drained soils that formed in highly weathered, old alluvium derived from glacial till material. These soils are on long, low side slopes and rounded ridgetops that grade to river valleys. Slopes are 9 to 18 percent.

These soils are in association with the loess-derived soils on benches and are upslope from and adjacent to the Caleb soils. They are also in complexes with Caleb and Clanton soils. They are most common along the Middle River, Grand River, and West Branch Creek but they are in small areas along all the major streams. The native vegetation was grass and trees.

In a representative profile, the surface layer is very dark grayish-brown loam about 8 inches thick. The subsurface layer is loam or silt loam that contains enough sand to have a gritty feel. It is about 5 inches thick and is dark grayish brown mixed with very dark gray and grayish brown. The subsurface layer is light brownish gray when dry.

The subsoil extends to a depth of 60 inches. The upper 12 inches of the subsoil is brown or strong-brown clay loam that is friable in the upper 5 inches and firm below. It has a few strong-brown mottles. The next part of the subsoil, to a depth of about 46 inches, is brown clay loam that is mottled with reddish brown and yellowish red. It is somewhat firmer than the upper part of the subsoil. The lower part of the subsoil, beginning at a depth of about 46 inches, is firm, brown clay loam that is mottled with grayish brown and contains sand strata. There is stratified sandy loam at a depth of about 60 inches.

The Mystic soils have high available water capacity and are slow in permeability. In places they are seepy and wet near their contact with more permeable soils upslope. Mystic soils are medium acid to very strongly acid in the most acid part of the subsoil, but they range from neutral to medium acid in the surface layer. Their organic-matter content is low to medium. These soils are very low to low in available nitrogen and phosphorus and are low in available potassium. They have a deep, favorable root zone.

Some areas of Mystic soils are suited to crops, but most are better suited to pasture and are presently used for pasture. These soils are in small areas and are not extensive. Consequently, they are managed with other soils. Control of rapid runoff and erosion is the principal concern of management.

Representative profile of Mystic loam, 9 to 14 percent slopes, moderately eroded, 380 feet west and 1,900 feet south of the northeast corner of sec. 32, T. 74 N., R. 29 W., in a pasture on a bench having a slope of 9 percent:

A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) loam; grayish brown (10YR 5/2) when dry; weak, fine, granular structure; friable; neutral (pH 6.7); clear, smooth boundary.

A2—8 to 13 inches, mixed very dark gray, dark grayish-brown, and grayish-brown (10YR 3/1, 4/2, and 5/2) loam or silt loam; common, distinct, light brownish-gray (10YR 6/2 when dry) grainy coatings; weak, medium, platy structure breaking to weak, fine, subangular blocky structure; friable; common pores; neutral (pH 6.7); gradual, smooth boundary.

B1—13 to 18 inches, brown (10YR 4/3) clay loam; weak, fine and very fine, subangular blocky structure breaking to fine, granular structure; friable; few pores; common, light brownish-gray (10YR 6/2 when dry) grainy coatings; slightly acid (pH 6.2); gradual, smooth boundary.

B21t—18 to 25 inches, strong-brown (7.5YR 5/6) heavy clay loam; faces of peds brown (7.5YR 4/4); few, fine, distinct, strong-brown (7.5YR 5/8) mottles; moderate, fine and very fine, angular and subangular blocky structure; firm; thin, dark-brown (7.5YR 3/2), discontinuous clay films; few pores; very strongly acid (pH 4.8); gradual boundary.

B22t—25 to 35 inches, mixed brown (7.5YR 5/4) and reddish-brown (5YR 4/4) heavy clay loam; few, fine, distinct, yellowish-red (5YR 5/6 and 5/8) mottles; moderate, medium, subangular blocky structure; firm; thin, discontinuous clay films on vertical ped faces; few, fine, black oxides; very strongly acid (pH 4.7); gradual, smooth boundary.

B23t—35 to 46 inches, brown (10YR 5/3) heavy clay loam; common, fine, distinct, reddish-brown and yellowish-red (5YR 4/4 and 4/6) mottles; moderate, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; firm; common, fine, black oxides; medium, continuous clay films on prism faces; nearly continuous clay films on blocky ped faces; very strongly acid (pH 4.9); gradual, smooth boundary.

IIB3t—46 to 60 inches, brown (10YR 5/3) clay loam; common, medium, distinct, brown (7.5YR 4/4) and grayish-brown (2.5Y 5/2) mottles; moderate, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; firm; common, medium, black oxide; thick, continuous clay films on prism faces; weakly stratified with thin strata of loam in the lower part; very strongly acid (pH 4.9).

The surface layer is loam, light clay loam, or silt loam that contains enough sand to have a gritty feel. This layer ranges from 6 to 10 inches in thickness. The subsurface layer has about the same range as the surface layer in thickness and texture. In uneroded areas the surface layer is darker colored. In eroded areas where the original surface layer was less than 6 inches thick, it is mixed with the subsurface layer through plowing, and color of the present surface layer ranges from very dark gray to very dark grayish brown. The subsoil is 24 to about 60 inches thick and is brown to reddish brown. In some places there is gray mottling, but strong-brown and reddish mottles are always present, though they vary widely in size and amount. In some areas the subsoil is light clay. The substratum ranges from clay loam to light sandy loam and has a wide range of brown, gray, and strong brown.

The Mystic soils differ from Caleb soils in having a thick, more clayey subsoil that is red or has reddish mottling. Mystic soils are similar to the Keswick soils in subsoil color and drainage, but they have more stratification in the lower part of the subsoil and in the substratum than the Keswick soils, which formed in glacial till.

Mystic loam, 9 to 14 percent slopes, moderately eroded (MtD2).—This soil is on rounded ridgetops and the upper side slopes of high benches. It is in small areas near all the major streams and tributaries of the county. This soil is downslope from and adjacent to Ladoga soils on benches. In a few places, it is downslope from and adjacent to the Gara or Shelby soils.

This soil has the profile described as representative for the series. In many places, however, the surface layer is only 3 to 7 inches thick. In most places this layer and the subsurface layer have been mixed through plowing, and the plow layer is very dark grayish brown.

Included with this soil in mapping were small areas of moderately sloping soils, small areas of uneroded soils, and small areas of severely eroded soils, all of the Mystic series. Also included were small areas of adjacent soils having the same slope.

This soil is poorly suited to row crops even if erosion is controlled and fertility is improved. It is managed with adjacent soils and is used for both cropland and pasture, but the larger acreage is in pasture.

In some places there are seepy bands along the area of contact with more permeable soils upslope. Runoff is very rapid, and controlling erosion is the major concern in management of this soil. The soil tilth is normally poor. If the wetness, fertility, and erosion problems are controlled, some areas can be used for crops. The soil has fewer limitations for pasture. (Capability unit IVe-2; woodland suitability group 7)

Mystic-Clanton complex, 9 to 14 percent slopes, moderately eroded (MyD2).—This complex is on side slopes of very high, upland benches that have uneven topography. It is adjacent to and downslope from the Ladoga or Lamoni soils. Most areas are upslope from the Clanton or Gosport soils, but in some places the complex is upslope from the moderately steep Mystic-Clanton complex. Small areas of Lamoni soils are also in this complex.

This complex consists of Mystic and Clanton soils that occur in such intricate patterns on the landscape that they were not separated on the soil map. Mystic soils make up about 60 percent of the complex, and Clanton soils nearly 40 percent. These soils have profiles similar to those described as representative for their respective series.

The Mystic soils are upslope from the Clanton soils. In most areas some glacial material is mixed with shale in the profile.

This complex is unsuited to row crops, but some areas are managed as cropland with adjacent, more suitable soils upslope. Most of the acreage is in pasture. Runoff is rapid because of strong slopes and slow permeability, and there is a serious hazard of erosion. Hillside waterways that gully readily are present in many places. (Capability unit VIe-3; woodland suitability group 7)

Mystic-Clanton complex, 14 to 18 percent slopes, moderately eroded (MyE2).—This complex is adjacent to and downslope from the Lamoni soils or the strongly sloping Mystic-Clanton complex. In most places it is upslope from the Clanton soils or Gosport soils.

The profiles of the Mystic and Clanton soils in this complex are similar to the ones described as representative for their respective series. Mystic soils make up about 50 percent of the mapping unit, and Clanton soils most of the remaining 50 percent.

Included with these soils in mapping were small, severely eroded areas in which the subsoil is exposed.

This complex is not suited to row crops, and most areas are in pasture. Runoff is rapid because of the moderately steep slopes and slow permeability. Erosion is a very serious hazard, and parts of these areas are limited by droughtiness. The soils are low in organic-matter content.

Although the shale-derived soils in this complex are droughty, average pasture can be produced, especially early in summer and late in fall, if erosion is controlled and grass is established. (Capability unit VIIe-2; woodland suitability group 7)

Nevin Series

The Nevin series consists of deep, dark-colored, somewhat poorly drained soils that formed in silty alluvium on second bottoms in all parts of the county. These are level to gently sloping soils having slopes of 0 to 5 percent. They are on low stream benches or second bottoms. They are seldom subject to flooding, but some areas are flooded by tributary streams.

The Nevin soils are commonly adjacent to the more poorly drained Bremer soils and the moderately well drained Wiota soils. In some areas they are in slightly elevated positions just above the Kennebec and Zook soils on first bottoms that have steep, low escarpments. They are in fairly large areas along all the major streams. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown silty clay loam about 17 inches thick. The subsoil extends to a depth of about 50 inches. It is dark grayish-brown silty clay loam to a depth of 40 inches. This layer has firm consistence in the lower part and is mottled with brown. At a depth of more than 40 inches, the subsoil is dark-gray, firm silty clay loam that is mottled with dark grayish brown and brown. Sand grains are present in this layer and increase in the underlying substratum, which is similar in other respects to the lower part of the subsoil.

The Nevin soils have high available water capacity and are moderately slow in permeability. They have some surface drainage, and water therefore drains from their surface layer. Nevin soils are high in organic-matter content and slightly acid in the surface layer. They are low in available nitrogen, medium to high in available phosphorus, and low to medium in available potassium. These soils have a deep, favorable root zone.

Nearly all areas of the Nevin soils are in crops. These soils are commonly intermingled with areas of more poorly drained or better drained soils and managed with these soils. Tile drains are beneficial along depressed drainageways within the area. Some of the more sloping areas are subject to slight erosion.

Representative soil profile of Nevin silty clay loam, 0 to 2 percent slopes, 2,200 feet east and 220 feet north of the southwest corner of sec. 11, T. 75 N., R. 28 W., in a cultivated field:

Ap—0 to 8 inches, very dark brown (10YR 2/2) light silty clay loam; dark grayish brown (10Y 4/2) when dry; weak, fine, granular structure; friable; slightly acid (pH 6.4); clear, smooth boundary.

A3—8 to 17 inches, very dark grayish-brown (10YR 3/2), light silty clay loam; faces of peds very dark gray (10YR 3/1); dark gray (10YR 4/1) when dry; weak, medium, granular structure to fine subangular blocky structure; friable; few clean sand grains on ped surfaces; slightly acid (pH 6.4); gradual, smooth boundary.

B1—17 to 29 inches, dark grayish-brown (10YR 4/2) silty clay loam; faces of peds very dark grayish brown (10YR 3/2); weak to moderate, fine, subangular blocky structure; friable; some clean sand grains; very dark gray (10YR 3/1) stains in some root channels; slightly acid (pH 6.3); gradual, smooth boundary.

B2t—29 to 40 inches, dark grayish-brown (10YR 4/2) silty clay loam; common, fine, faint to distinct, brown (10YR 4/3 and 7.5YR 4/4) mottles; weak, fine, subangular blocky structure; firm; some clean sand grains; few roots; very few, thin, discontinuous clay films; few dark-gray (10YR 3/1) organic coatings on ped faces; slightly acid (pH 6.4); gradual, smooth boundary.

B3g—40 to 50 inches, dark-gray (10YR 4/1) silty clay loam; common, medium, faint, dark grayish-brown (10YR 4/2) mottles and common, fine, distinct, brown (7.5YR 4/4) mottles; weak, coarse, subangular blocky structure; firm; sand grains increasing with depth; few roots; common, fine tubular pores; dark-gray (10YR 3/1) organic stains on vertical ped faces and in root channels; neutral (pH 6.6); gradual, smooth boundary.

C—50 to 60 inches, same as B3 horizon except increasing sand content and common to many, medium to coarse, brown (7.5YR 4/4 and 10YR 5/3) to yellowish-brown (10YR 5/4) mottles.

The surface layer ranges from 10 to 18 inches in thickness and from very dark grayish brown and very dark brown to black in color. In some areas it is heavy silt loam. The subsoil is more compact and is light to medium silty clay loam. It ranges from 20 to 36 inches in thickness. The dominant color is dark grayish brown, and the proportion and size of the gray and brown mottles are variable. Yellowish brown and strong brown occur in the subsoil in some areas. The substratum has a wider range of color and texture. It is mainly very dark gray to gray but is grayish brown in places, and it ranges from heavy silty clay loam that contains a few sand grains to light clay loam. There is a wide variation in amount of brown mottling. In some places sandy strata are present at a depth of 48 to 60 inches.

The Nevin soils are better drained and have a less gray, less clayey subsoil than the Bremer soils. In addition, Nevin soils generally do not have the black surface layer of Bremer soils. Nevin soils are more poorly drained than the Wiota soils and, unlike those soils, have a mottled grayish subsoil.

Nevin silty clay loam, 0 to 2 percent slopes (NeA).—This nearly level soil is on second bottoms. It is at higher elevations than adjacent soils on first bottoms and poorly drained soils on second bottoms. It is adjacent to the Bremer soils on wide stream benches, and to the Wiota on slopes near the boundary of benches and first bottoms. In some places this soil is adjacent to higher loess-covered benches that extend away from the stream toward the uplands. In other areas the outer boundary is a short, abrupt escarpment adjacent to Kennebec and Nodaway soils on first bottoms.

This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of the more poorly drained Bremer soils and the better drained Wiota soils. Also included were very small areas of the Zook and Colo soils along drains and lower depressions.

There is a wide range in size of individual areas. Consequently, this soil is managed with adjacent soils. It is well suited to row crops. Only small, irregularly shaped areas adjacent to less suitable soils are in pasture.

This soil does not require tile drains in most places, but tile is beneficial in areas where inclusions of poorly drained soils are most common. This soil is not subject to erosion and is flooded only at times of very high water. (Capability unit I–2; woodland suitability group 8)

Nevin silty clay loam, 2 to 5 percent slopes (NeB).—This gently sloping soil is downslope from the level Nevin or Bremer soils, and it slopes gradually to the Colo, Kennebec, or Nodaway soils on first bottoms. It contains short drainageways, and these make the topography irregular.

The profile of this soil differs from that described as representative for the series because the surface layer is not quite so thick and the subsoil contains more brown with dark gray and grayish brown. The surface layer averages about 12 inches in thickness.

Included with this soil in mapping were small areas of the better drained Wiota soils and narrow areas of more poorly drained Bremer and Colo soils.

This soil is well suited to row crops if erosion is controlled. Where it is in small areas, it is managed with adjacent soils. It is subject to moderate runoff and erosion. Waterways and slopes are short, and erosion normally is only slight. Some drainageways benefit from tile drainage. (Capability unit IIe–1; woodland suitability group 8)

Nira Series

The Nira series consists of deep, dark-colored, moderately well drained soils of the uplands that formed in brown and gray loess under prairie grasses. These soils are most common southeast of Clanton Creek in Ohio and Walnut Townships, but small areas are in all parts of the county. Slopes range from 5 to 9 percent.

The Nira soils are on the upper part of side slopes below Macksburg or Sharpsburg soils, and they are above Lamoni and Clarinda soils.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown light to medium silty clay loam about 17 inches thick. The upper part of the subsoil is brown, friable medium silty clay loam. The lower part is grayish-brown light silty clay loam that is distinctly mottled with brown, strong brown, and yellowish brown. The substratum is friable light silty clay loam. It is grayish brown or olive gray and is highly mottled with strong brown and yellowish brown. The detailed profile that is described as representative for the series is not described to a depth great enough to show the substratum.

The gray color in the lower part of the subsoil is not an indication of present drainage or aeration conditions in these soils. This color was inherited from the loess. The gray was formed (deoxidized) before the Nira soils developed.

Nira soils have high available water capacity and are moderately slow in permeability. They are typically slightly acid to medium acid in the surface layer unless limed. They are low to medium in available nitrogen, low in available phosphorus, and medium to high in available potassium. They have a deep, favorable root zone. Most of the acreage of Nira soils is moderately eroded and low to medium in organic-matter content.

Nira soils are suited to crops. Most areas are cultivated, but some are in pasture. The areas are commonly small in size, and many of them are managed with adjacent soils. Runoff is medium to rapid, and the major hazard is erosion. Some eroded areas are in poor tilth.

Representative profile of Nira silty clay loam, 5 to 9 percent slopes, moderately eroded, 740 feet east and 1,540 feet north of the southwest corner of sec. 14, T. 74 N., R. 26 W., in a cultivated field on a slope of 7 percent:

Ap—0 to 7 inches, very dark brown (10YR 2/2) light silty clay loam; weak, fine, granular structure; friable; neutral (pH 7.0); gradual, smooth boundary.

A1—7 to 12 inches, very dark grayish-brown (10YR 3/2) light silty clay loam; faces of peds very dark brown (10YR 2/2); weak, very fine, subangular blocky structure; friable; neutral (pH 7.0); gradual, smooth boundary.

A3—12 to 17 inches, very dark grayish-brown (10YR 3/2) medium silty clay loam; some very dark gray (10YR 3/1) coatings on ped faces; weak, medium, subangular blocky structure, breaking to moderate, very fine, subangular blocky structure; friable; medium acid (pH 6.0); gradual, smooth boundary.

B21t—17 to 23 inches, brown (10YR 4/3) medium silty clay loam; few, fine, distinct, yellowish-brown (10YR 5/4 and 5/6) mottles; moderate, fine, subangular blocky structure; friable; thin, discontinuous clay films; few dark oxides; medium acid (pH 5.8); gradual, smooth boundary.

B22t—23 to 36 inches, grayish-brown (2.5Y 5/2) medium silty clay loam; common, fine, distinct, yellowish-brown (10YR 5/4) mottles and few, prominent, strong-brown (7.5YR

5/6) mottles; moderate, medium and fine, subangular blocky structure; firm; thin, discontinuous clay films; deoxidized and leached weathering zone; few dark oxides; medium acid (pH 5.8); gradual, smooth boundary.

B3—36 to 50 inches, grayish-brown (2.5Y 5/2) light silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) and brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; friable; deoxidized and leached weathering zone; common, fine, black oxides; slightly acid (pH 6.2); gradual, smooth boundary.

The surface layer is black, very dark brown, or very dark gray and is 10 to 20 inches thick. In moderately eroded areas, plowing mixes subsoil material into the surface layer, which then is very dark grayish brown light to medium silty clay loam in most places. The subsoil is 18 to 36 inches thick. In most places the upper few inches is brown, but the subsoil generally has some grayish brown. There is a wide range in the color and amount of mottling. The substratum and lower part of the subsoil have little range in texture and color, but they range widely in amount and kind of mottles. The loess mantle in which the Nira soils were formed ranges from 4 to 8 feet in thickness. This is underlain by a buried, gray clayey soil that formed in glacial till.

The Nira soils have a grayer, more mottled subsoil than the Sharpsburg soils and are lower in clay content in the subsoil. They are better drained than the Clearfield soils and do not have profiles with a buried clayey soil (gumbotil). Nira soils have a subsoil that is browner in the upper part and less clayey than that of the Macksburg soils. Also, their surface layer is not so dark colored or so thick as that of the Macksburg soils, and they are better drained.

Nira silty clay loam, 5 to 9 percent slopes, moderately eroded (NIC2).—This soil is on the upper part of side slopes. It is adjacent to and downslope from the gently sloping Macksburg and Sharpsburg soils, and upslope from the Clarinda and Lamoni soils. In some places it is also adjacent to areas of the Clearfield soils that are on slopes forming bowllike areas. Slopes are irregular and are crossed by hillside waterways. Some waterways contain small gullies.

The surface layer is thinner in some places than is typical. It is mixed with part of the subsoil in some cultivated areas and is very dark grayish brown.

Included with this soil in mapping were small, less sloping areas and small areas where erosion has been slight or severe. Also included were small areas of adjacent soils, such as the poorly drained Clearfield soils. Included areas that are significant to management are indicated on the soil map by the symbols for severely eroded spots or wet spots.

This soil is moderately suited to row crops if erosion is controlled. Most of it is in crops and managed with the adjacent soils upslope. Most waterways are crossable, but small gullies form in some places. (Capability unit IIIe-1; woodland suitability group 3)

Nodaway Series

The Nodaway series consists of deep, stratified, moderately well drained, nearly level soils that formed in recent silty alluvium on first bottoms. These soils are near major streams and tributaries in the eastern part of the county in association with the Kennebec and Spillville soils and Alluvial land. They occupy positions nearest the stream and are subject to flooding. The native vegetation is grass and trees.

These recent alluvial deposits of silt loam have not developed a soil profile, but the surface layer is darkened in places. The surface layer is 6 inches of very dark grayish-brown silt loam. This is underlain by stratified layers of very dark grayish-brown, dark grayish-brown, dark-gray, and grayish-brown, friable silt loam, together with thin layers of loam and sandy loam. Some brownish mottles are present in the lower part, as well as thin strata of yellowish-brown or gray sand.

The Nodaway soils have high available water capacity and are moderate in permeability. They are neutral to slightly acid throughout, and their organic-matter content is moderately low. These soils are low in available nitrogen, low to medium in available phosphorus, and medium in available potassium. They have a deep, very favorable root zone.

Nodaway soils are moderately fertile and are in crops, pasture, and woodland. Channeled areas are not suitable for crops. These soils are subject to flooding, and this is the main hazard to their use for crops. They can be worked soon after rains, and the silty surface layer is easily tilled.

Representative profile of Nodaway silt loam, 120 feet north and 240 feet west of the southeast corner of the NE¼NW¼ sec. 7, T. 75 N., R. 27 W., in a nearly level cultivated field:

Ap—0 to 6 inches, very dark grayish-brown (2.5Y 3/2) silt loam; grayish brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2) when dry; weak, medium, granular structure to weak, fine, granular structure; friable; neutral (pH 7.0); clear, smooth boundary.

C—6 to 60 inches, stratified, very dark grayish-brown (2.5Y 3/2), dark grayish-brown (2.5Y 4/2), dark-gray (10YR 4/1), and grayish-brown (2.5Y 5/2) coarse silt loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles on horizontal cleavage surfaces; structureless (massive); some horizontal cleavage; friable; few thin strata of grayish brown (2.5Y 5/2) loam and sandy loam; neutral (pH 6.8).

Thickness of the surface layer corresponds to the thickness of the plow layer. Some areas contain recent fine sand or coarse silt deposits on the surface. In some areas the surface layer is very dark gray. The stratified layer below is commonly several feet thick. Strata of grayish-brown coarse silt in places contain very thin (1 inch or less), very fine, grayish-brown sand layers. Layers of silty clay loam are in a few places. Some areas are underlain by sand at a depth of 4 to 6 feet.

The Nodaway soils differ from the Kennebec soils in being lighter colored below the surface layer, in containing more sand and silt lenses, and in being stratified. They are more stratified and lighter colored throughout and contain more silt than the loamy Spillville soils. They lack the distinct subsurface layer and brown subsoil present in the Martinsburg soils, and they are lower in clay content throughout.

Nodaway silt loam (0 to 2 percent slopes) (Nm).—This nearly level soil is on first bottoms near major streams and tributaries. On wider bottoms it is adjacent to the Colo soils, which are farther away from the streams. On some narrow bottoms, it is adjacent to the Martinsburg soils.

Included with this soil in mapping were small areas of the Spillville soils and Alluvial land. Recent sandy deposits are in many areas. Larger areas of sandy deposits up to about 2 acres in size are indicated on the soil map by the symbol for sand spots.

In some years the use is limited by frequent flooding, but the soil is well suited to row crops. It has good surface drainage from small drains. It dries readily and has excellent tilth. Most flooding occurs before row crops are planted.

Individual areas are irregular in shape and size, but most are long and narrow. Some are dissected by channels or intermittent streams extending from the uplands. Most larger areas are in crops and are managed with adjacent soils. Some smaller areas are managed with adjacent soils as pasture or woodland. Where access for machinery is available, some areas on narrow bottoms presently in timber or brushy pasture are being cleared and are in pasture or cultivated crops. (Capability unit I–3; woodland suitability group 10)

Nodaway silt loam, channeled (0 to 2 percent slopes) (Nn).—This soil is in narrow areas adjacent to very meandering streams or deep, curving, old stream channels. It is adjacent to the Colo, Kennebec, Spillville, and other Nodaway soils.

The profile of this soil is similar to that described as representative for the series, but some parts of individual areas are darker in the surface layer and throughout.

Included with this soil in mapping were the meandering streams, many deep channels, some side gullies, and small areas of the adjacent soils. Individual areas are long and narrow and are parallel to the general course of the streams on both sides.

This soil is not suited to row crops, because many noncrossable streams are present. Most areas are in trees or other woody plants. Some are in pasture. The soil is flooded frequently and is not accessible to heavy machinery. Stream straightening and filling of old channels in some areas reduce the risk of flooding. (Capability unit Vw–1; woodland suitability group 10)

Nodaway-Martinsburg silt loams, 2 to 5 percent slopes (NoB).—This complex is in very narrow, alluvial areas along small streams in wooded areas. It is adjacent to the moderately steep and steep Gosport and Lindley soils on uplands. In a few places it is adjacent to larger areas of the Martinsburg soils on foot slopes.

Areas of this complex consists of nearly level Nodaway soils on narrow flood plains and Martinsburg soils having slopes of 2 to 5 percent at the foot of upland side slopes. They are most common in the east-central part of the county. The individual soils are in very narrow areas that cannot be separated on the soil map.

Nodaway soils make up about 60 percent of this mapping unit, and Martinsburg soils almost all the remaining 40 percent. The profiles of both Nodaway and Martinsburg soils are similar to the ones described as representative for each series.

Included in mapping were many areas of noncrossable streams. In most places the streams are relatively wide and deep. Bank cutting is common, and gullies form readily in side drains. The soils are flooded frequently and are subject to silting. Recent sandy deposits occur in some areas.

These soils are not suited to row crops. Most areas are managed as pasture or woodland pasture with adjacent sides slopes. Gully control and stream straightening help to stabilize streambanks. Some areas now in trees are used for woodland and wildlife habitat. (Capability unit Vw–1; woodland suitability group 10)

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Nordness Series

The Nordness series consists of moderately dark colored, well-drained, shallow soils of the uplands that formed in a thin layer of mixed glacial till, loess, and weathered limestone. These soils are shallow over solid limestone bedrock. They are inextensive in the county but locally are important in the limestone areas.

These soils occur in association with limestone ledges and outcrops along the North and Middle Rivers and Clanton Creek. They have slopes of 15 to 25 percent. They are commonly downslope from the Gara and Shelby soils and just above limestone ledges and Steep rock land. Individual areas are small, and those less than 3 acres in size are shown on the soil map by the symbol for a rock outcrop within areas of other soils. The native vegetation was trees and prairie grasses.

In a representative profile, the surface layer is very dark gray loam about 4 inches thick. It contains a few small fragments of limestone. The subsoil is dark grayish-brown to olive-brown, friable silty clay loam about 8 inches thick. It contains a few, fine, yellowish-brown mottles. Hard limestone bedrock is at a depth of about 12 inches. The upper part of the limestone is fragmented, and some smaller fragments appear in the surface layer and the subsoil.

The Nordness soils absorb water readily and are moderate in permeability. Because they are shallow to limestone bedrock, they have very low available water capacity, are droughty, and have a shallow, unfavorable root zone. These soils do not need lime. They are very low or low in available potassium and phosphorus and are low to medium in organic-matter content.

The Nordness soils have severe limitations for pasture because large fragments of limestone make reseeding and management difficult in most areas. Farm equipment cannot be used safely in most places. Most areas are in woodland. If pastures are overgrazed or if the trees are removed, Nordness soils are subject to severe erosion, which exposes lime fragments on the surface.

Representative profile of Nordness loam, 15 to 25 percent slopes, 140 feet west and 260 feet north of the southeast corner of sec. 35, T. 75 N., R. 27 W., in a woodland pasture:

A1—0 to 4 inches, very dark gray (10YR 3/1) loam; moderate, medium, granular structure; friable; few small flagstones of limestone; mildly alkaline (pH 7.8); gradual, smooth boundary.

Bt—4 to 12 inches, dark grayish-brown to olive-brown (2.5Y 4/2 to 4/4) medium silty clay loam that is high in content of sand; fine, faint, yellowish-brown (10YR 5/4) mottles; moderate, fine, subangular blocky structure; friable; thin, discontinuous clay films; neutral (pH 6.8); abrupt, smooth boundary.

IIR—12 inches +, hard limestone; fragmented so that limestone fragments are common on the surface.

In most places the surface layer and subsoil combined are so thin that lime fragments appear on the surface. The surface layer ranges from loam to light clay loam in texture, from black to very dark grayish brown in color, and from about 2 to 10 inches in thickness.

In places the brownish subsoil is absent and the dark surface layer is underlain directly by hard limestone. In other places the surface layer is very thin and the subsoil is firm loamy material. The depth to bedrock ranges from 8 to 20 inches.

The subsoil has grayer hues than is within the defined range for the series, but this does not alter the usefulness or behavior of these soils.

Nordness soils differ from Sloping stony land in being shallow to continuous, solid limestone bedrock. They are shallower to limestone than Dunbarton soils and lack the clayey subsoil that is present in those soils.

Nordness loam, 15 to 25 percent slopes (NrE).—This soil is along the North and Middle Rivers and Clanton Creek. It is moderately steep to steep. It is commonly downslope from the Gara and Shelby soils and just above limestone ledges and Steep rock land.

Included with this soil in mapping were small areas of adjacent Gara soils and outcrops of limestone bedrock.

This soil is not suited to crops and has severe limitations for pasture. Owing to the thinness of soil layers over bedrock and the moderately steep to steep slopes, the soil is subject to severe erosion and is droughty. Runoff is rapid or very rapid because the thin, moderately permeable subsoil is quickly saturated. Some areas contain shallow gullies cut down to bedrock with many limestone fragments on gully banks.

This soil is in narrow areas and is managed with adjacent soils. A few areas are quite long. Most areas are presently in wooded pasture or woodland (fig. 15). In many places farm equipment cannot be used because of rock and steepness of slopes, and renovation of pastures is difficult. Wildlife habitat is another possible use. (Capability unit VIIe-3; woodland suitability group 1)

Olmitz Series

The Olmitz series consists of deep, dark-colored, moderately well drained to well drained soils that formed in loamy alluvium at the base of upland slopes. This alluvial material washed off the adjacent slopes occupied by Gara and Shelby soils.

Olmitz soils are gently sloping to moderately sloping and are on narrow foot slopes between the steeper, till-derived soils upslope and the more nearly level, alluvial soils downslope on first or second bottoms. They are also on alluvial fans at the mouth of drainageways. They are near streams in all parts of the county but are most common along the major streams. Slopes range from 2 to 9 percent. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black to very dark brown loam and very dark brown to very dark grayish-brown light clay loam about 30 inches thick. The subsoil is dark-brown, friable light clay loam that extends to a depth of about 55 inches. The substratum is typically dark-brown or brown light clay loam that has a few gray and yellowish-brown mottles that increase in size and number with depth. The detailed profile that is

Figure 15.—Area of Nordness loam, 15 to 25 percent slopes, near town of Peru in eastern part of county. Flaggy limestone is on the surface.

given as representative for the series is not described to a depth great enough to show the substratum.

The Olmitz soils have high available water capacity and are moderate in permeability. They commonly receive runoff from soils that are upslope. They are typically medium acid in the surface layer unless limed, and they are medium in organic-matter content. They are low in available nitrogen and phosphorus and are medium in available potassium. They have a deep, favorable root zone.

Olmitz soils are subject to erosion. In places runoff from adjacent slopes concentrates in drainageways and causes gullying. Some deposition occurs where the soils are gently sloping.

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

Representative profile of Olmitz loam, 2 to 5 percent slopes, 740 feet east and 1,940 feet north of the southwest corner of sec. 30, T. 77 N., R. 26 W., in a cultivated field on a south-facing slope of 3 percent near a road:

Ap—0 to 7 inches, black (10YR 2/1) to very dark brown (10YR 2/2) loam; grayish brown (10YR 5/2) when dry; moderate, fine, granular structure; friable; medium acid (pH 5.8); clear, smooth boundary.

A11—7 to 15 inches, very dark brown (10YR 2/2) light clay loam; grayish brown (10YR 5/2) when dry; moderate, very fine and fine, subangular blocky structure; friable; medium acid (pH 5.8); gradual, smooth boundary.

A12—15 to 23 inches, very dark brown (10YR 2/2) light clay loam; moderate, fine and very fine, subangular blocky structure; friable; medium acid (pH 5.8); gradual, smooth boundary.

A3—23 to 30 inches, very dark grayish-brown (10YR 3/2) light clay loam; very dark brown (10YR 2/2) organic coatings on some ped faces; moderate, fine, subangular blocky structure; some very fine blocky structure; some weak, vertical cleavage; friable; few pebbles (2 to 5 millimeters); medium acid (pH 6.0); gradual, smooth boundary.

B2—30 to 48 inches, dark-brown (10YR 3/3) light clay loam; weak, medium, prismatic structure, breaking to weak, coarse, blocky structure, breaking to weak, very fine and fine, subangular blocky structure; friable; many pebbles (2 to 5 millimeters); slightly acid (pH 6.2); gradual, smooth boundary.

B3—48 to 55 inches, dark-brown (10YR 3/3) light clay loam; weak, fine, subangular blocky structure, to massive; friable; few to common, very fine, tubular pores; slightly acid (pH 6.5).

The surface layer ranges from 24 to 36 inches in thickness and from black to very dark grayish brown in color. Because there is a wide range in the amount of sand, the surface layer ranges from sandy loam to light clay loam but is mostly loam. In some places there is mottling or mixing of lighter brown in the subsoil, and there is some grayish brown in the lower part. The subsoil is light to medium clay loam. The combined thickness of the surface layer and subsoil ranges from 36 to 60 inches. The substratum ranges from dark-brown to dark yellowish-brown loam to clay loam. Some mottling is present, and some areas contain more sand than others.

The Olmitz soils differ from the Judson soils in being more loamy throughout. They are more loamy than the Ely soils, and in contrast to those soils, they do not have mottles in the upper part of the subsoil. The Olmitz soils differ from the Arbor soils in having a thicker surface layer and in being more friable in the lower part of the subsoil and the substratum. They do not have glacial till in their profile as do the Arbor soils.

Olmitz loam, 2 to 5 percent slopes (OmB).—This gently sloping soil is on fan-shaped alluvial deposits at the mouth of small, hillside waterways and on narrow foot slopes. The areas typically are adjacent to and below areas of Gara and Shelby soils and are upslope from the Colo and other soils on adjacent bottom lands. This soil is in small areas in all parts of the county along major streams and their tributaries. It is not extensive but is locally important. It has the profile described as representative for the series.

Included in mapping were small areas of moderately sloping Olmitz soils and small areas of gently sloping, more poorly drained alluvial soils near the lower boundary of areas mapped as this soil.

This soil is well suited to row crops if runoff and siltation are controlled. Most of this soil is in small areas that are managed with adjacent soils as cropland or pasture. This soil is subject to slight erosion due to runoff from the adjacent more sloping Gara and Shelby soils. Some deposition occurs in the less sloping areas. Lessening of runoff from the adjacent side slopes is the most effective way to control erosion on this soil. Most areas are in good tilth. (Capability unit IIe-2; woodland suitability group 4)

Olmitz Loam, 5 to 9 percent slopes (OmC).—This soil is moderately sloping and is on narrow foot slopes, downslope from Gara and Shelby soils. It normally is upslope from the gently sloping Olmitz soils. In some places it extends downslope to the more poorly drained bottom lands.

The profile of this soil is similar to that described as representative for the series. This soil, however, has a thinner surface layer. This layer ranges from 20 to 24 inches in thickness and is very dark gray or very dark grayish brown. In some areas this soil is underlain by glacial till at a depth of 40 or more inches.

Included with this soil in mapping were small areas of the Arbor soils and the gently sloping Olmitz soils.

If runoff and siltation are controlled, this soil is moderately suited to row crops. Most of the acreage is in pasture and is managed with adjacent side slopes. Some of it is cropped with less sloping soils downslope.

If cultivated, this soil is subject to deposition of sandy materials from upslope and to rilling and gullying. Control of runoff and erosion on the soils upslope, or diversion of runoff, is necessary to control erosion and siltation on this soil. (Capability unit IIIe-1; woodland suitability group 4)

Sharpsburg Series

The Sharpsburg series consists of dark-colored, moderately well drained soils of the uplands that formed in loess under prairie grasses. These are the most extensive soils in the county, and they are in all parts of the county. These soils are level to gently sloping on divides and gently sloping to strongly sloping on side slopes. On narrow rounded divides where slopes are 2 to 9 percent, they are on the entire ridgetop. On broad divides they are downslope from and adjacent to the Macksburg soils.

The Sharpsburg soils are upslope from and adjacent to the Clarinda, Lamoni, and Shelby soils, which formed in weathered glacial material. In places the Sharpsburg soils occupy entire side slopes and adjoin narrow bottom lands along small streams and tributaries. Some areas of

Sharpsburg soils are on high benches near the larger streams.

In a representative profile, the surface layer is very dark brown light silty clay loam about 11 inches thick. This is underlain by a grayish-brown and brown, friable silty clay loam layer about 4 inches thick. The upper part of the subsoil, at a depth of about 15 inches, is brown, firm to friable silty clay loam.

The lower part of the subsoil, beginning at a depth of about 29 inches, is grayish-brown silty clay loam that has grayish-brown and yellowish-brown mottles. It is less firm and compact than the upper part of the subsoil. The substratum is grayish-brown, mottled silty clay loam and is similar to the lower part of the subsoil. The detailed profile that is described as representative for the series is not described to a depth great enough to show the substratum.

The Sharpsburg soils have high available water capacity and are moderately slow in permeability. They are typically slightly acid or medium acid in the surface layer unless limed. They are low to medium in available nitrogen and available phosphorus and are medium to high in available potassium. In uneroded areas these soils are medium to high in organic-matter content. They have a very deep, favorable zone for root development.

Sharpsburg soils are commonly in crops. Nearly all the areas are in cultivation, though some small areas adjacent to more sloping soils are in pasture.

The major concern of management in sloping areas is controlling erosion. This hazard ranges from slight to severe, depending on past management and the degree of slope.

Representative profile of Sharpsburg silty clay loam, 2 to 5 percent slopes, 1,540 feet east and 2,060 feet north of the southwest corner of sec. 2, T. 76 N., R. 29 W., in a cultivated field on a southeast-facing slope of 4 percent:

Ap—0 to 7 inches, very dark brown (10YR 2/2) light silty clay loam; cloddy, breaking to weak, fine, granular structure; friable; neutral (pH 6.8); gradual, smooth boundary.

A1—7 to 11 inches, very dark brown (10YR 2/2) light silty clay loam; weak, very fine, subangular blocky structure; friable; slightly acid (pH 6.4); gradual, smooth boundary.

AB—11 to 15 inches, mixed very dark grayish-brown (10YR 3/2) and brown (10YR 4/3) silty clay loam; moderate, very fine, subangular blocky structure; friable; slightly acid (pH 6.4); gradual, smooth boundary.

B21t—15 to 21 inches, brown (10YR 4/3) silty clay loam; moderate, fine, subangular blocky structure; friable; thin, discontinuous clay films; slightly acid (pH 6.4); gradual, smooth boundary.

B22t—21 to 29 inches, brown (10YR 4/3) heavy silty clay loam; very few, fine, distinct, grayish-brown (10YR 5/2) mottles; moderate, fine, subangular blocky structure; firm; thin, continuous clay films; slightly acid (pH 6.5); gradual, smooth boundary.

B31t—29 to 36 inches, yellowish-brown (10YR 5/4) silty clay loam; few, fine, distinct, grayish-brown (10YR 5/2) mottles and few, fine, faint, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm; thin, discontinuous clay films; slightly acid (pH 6.5); gradual, smooth boundary.

B32—36 to 52 inches, grayish-brown (2.5Y 5/2) light silty clay loam; common, medium, prominent, brown (7.5YR 4/4) mottles and yellowish-brown (10YR 5/6) mottles; weak, coarse, blocky structure to massive; deoxidized and leached weathering zone; friable; neutral (pH 6.7).

There is a wide range in color and thickness of the surface layer. In nearly level areas this layer is 12 to 18 inches thick and nearly black. In eroded areas of the sloping soils, it is thinner and commonly very dark grayish brown. The surface layer is dark brown in places where the subsoil is exposed by erosion. The subsoil ranges from 18 to 40 inches in thickness. In some areas the upper and middle parts are free of mottling. The subsoil ranges from medium silty clay loam to light silty clay in the upper part. In some places the lower part of the subsoil is grayish brown, yellowish brown, or olive gray. The loess mantle in which the Sharpsburg soils formed is 10 to 15 feet thick on the level or gently sloping higher divides, but it ranges to as little as 4 feet thick on side slopes and high stream benches.

The Sharpsburg soils have a thinner surface layer and a browner subsoil, are less mottled, and are better drained than the Macksburg soils. They are darker colored and have a thicker surface layer than the Clinton and Ladoga soils, and they do not have the subsurface layer that is typical of those soils. Sharpsburg soils differ from the Nira soils in having a thicker brown subsoil that has more clay and a greater depth to grayish-brown colors.

Sharpsburg silty clay loam, 0 to 2 percent slopes (SbA).—This soil is on high, moderately wide ridges adjacent to the Macksburg soils on wide divides. Generally, this soil is adjacent to and extends from the Macksburg soils as a more narrow, nearly level ridge. Individual areas of this soil are small, narrow, and elongated.

This soil has a very dark brown to black surface layer that is about 18 inches thick. Mottling in the lower part of the subsoil is more evident than in the profile described as representative for the series. This soil generally is moderately well drained, but it is somewhat poorly drained in places.

Included with this soil in mapping were very small areas of Macksburg soils and gently sloping Sharpsburg soils.

This soil is well suited to row crops, and practically all of it is managed with the adjacent Macksburg and Sharpsburg soils as cropland. It is subject to very slight erosion, but this is generally not a serious hazard. The organic-matter content is high, and tilth commonly is good. (Capability unit I-1; woodland suitability group 3)

Sharpsburg silty clay loam, 2 to 5 percent slopes (SbB).—This gently sloping soil is mainly on narrow, gently rounded, upland divides and on side slopes. It is upslope from the moderately sloping Sharpsburg soils. Where ridges are narrow, it is on the entire ridgetop. In areas where ridges are broader, this soil is downslope from the nearly level Macksburg or Sharpsburg soils. In some areas it is adjacent to the Clearfield soils that are farther downslope along drainageways. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of gently sloping Macksburg soils. Also included were very narrow areas of poorly drained alluvial soils that are along hillside waterways too small to be mapped separately. Of these areas, the ones that are distinctly wet and up to about 2 acres in size are indicated on the soil map by the symbol for wet spots.

This soil is well suited to row crops if erosion is controlled. Individual areas range up to 100 acres in size. These areas are normally long and narrow, and they are managed with associated soils. Most of this soil is in crops, but small areas are in pasture or farmsteads.

This soil is high in organic-matter content and is fertile. Because the gentle slopes are long in some places, the soil is subject to slight erosion. (Capability unit IIe-1; woodland suitability group 3)

Sharpsburg silty clay loam, 2 to 5 percent slopes, moderately eroded (SbB2).—This soil is on high upland ridges and gentle side slopes and is in small areas within areas of less eroded, gently sloping Sharpsburg soils. It is generally on the more rounded, exposed parts of the landscape between waterways.

This soil has a very dark grayish-brown surface layer that is thinner than that of the soil having the representative profile. It is also less friable. Erosion has removed part of the original surface layer and its organic matter, and this has left only 4 to 8 inches of the original surface layer.

Included with this soil in mapping were small spots where erosion is less severe and very small areas of adjacent soils.

This soil is well suited to row crops if erosion is controlled. Most of this soil is in crops. The individual areas are small and are managed with the adjacent ridgetops. (Capability unit IIe-1; woodland suitability group 3)

Sharpsburg silty clay loam, 5 to 9 percent slopes (SbC).—This moderately sloping soil is on narrow ridgetops and the upper part of side slopes. It is mainly in the uplands but partly on high benches. It is commonly downslope from the gently sloping Macksburg and Sharpsburg soils. It is upslope from and adjacent to the Clarinda and Lamoni soils. In some areas it is upslope from the strongly sloping and moderately steep Shelby soils. Where ridgetops extend toward the major streams it is adjacent to the Ladoga soils.

The profile of this soil is similar to that described as representative for the series. Near the lower boundary of some areas, however, there is more gray mottling in the subsoil.

Included with this soil in mapping were small areas of the poorly drained Clearfield soils. Also included were small areas of more eroded and gently sloping Sharpsburg soils. Significant seepy areas or outcrops of glacial till are shown on the soil map by the symbol for wet spots or glacial till spots.

This soil is moderately well suited to row crops if erosion is controlled. Individual areas are irregular in size and shape, and most of them are managed with other soils as cropland.

The surface layer absorbs water readily and is in good tilth, but is subject to moderate erosion. Waterways on side slopes are well stabilized, but they begin cutting if the soil is cultivated intensively. (Capability unit IIIe-1; woodland suitability group 3)

Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded (SbC2).—This moderately sloping soil is on narrow ridges and on the upper part of side slopes. In most areas it is downslope from the gently sloping Sharpsburg soils and upslope from the Clarinda and Lamoni soils and the Shelby-Lamoni complex. Where ridgetops extend toward major streams, it is adjacent to the Ladoga soils. Slopes are irregular because of hillside waterways, and some waterways contain small gullies. The surface layer absorbs rainfall fairly well, but runoff is medium to rapid because of slope.

The surface layer of this soil is thinner and less friable than that of the soil having the profile described as representative for the series. This layer ranges from 3 to 7 inches in thickness and is mixed with the upper part of the subsoil. The resulting surface layer is very dark grayish brown and dark brown in places. The subsoil and underlying substratum are similar to those of the soil described as representative for the series.

Included with this soil in mapping were small areas that are slightly eroded or severely eroded. In places where hillside waterways are wide enough for alluvial soils to have formed, narrow areas of those soils also were included.

This soil is moderately suited to row crops if erosion is controlled. Nearly all of it is in crops (fig. 16). Most areas are large, and some are managed separately from other soils. The tilth is somewhat poor, and cloddiness is common in the most eroded places. Slopes are more irregular in shape and length than in other moderately sloping or gently sloping Sharpsburg soils. Most waterways are crossable, but small gullies form under intensive cultivation. (Capability unit IIIe-1; woodland suitability group 3)

Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded (SbD2).—This strongly sloping soil is on the upper part of side slopes. It is downslope from moderately sloping Sharpsburg soils and is upslope from moderately steep and steep Shelby soils. Near major streams it is adjacent to the Ladoga soils. Slopes are irregular.

In the profile of this soil, the surface layer is very dark grayish brown and dark brown. It is thinner and less friable than in the profile described as representative for the series. It is between 3 and 7 inches thick in most places and contains material from the upper part of the subsoil.

Included with this soil in mapping were small areas that are slightly eroded or severely eroded, and small areas of the adjacent Shelby or other Sharpsburg soils.

This soil is moderately suited to row crops if erosion is controlled. It is used for both crops and pasture and is managed with adjacent soils. Rapid runoff causes waterways to gully easily. Some areas are in poor tilth. (Capability unit IIIe-1; woodland suitability group 3)

Sharpsburg silty clay loam, benches, 0 to 2 percent slopes (ScA).—This soil is on high benches near major streams (fig. 17). It is adjacent to the Nevin and Wiota soils on second bottoms at slightly lower elevations. Upslope it is adjacent to the gently sloping Sharpsburg soils on benches or to the steeper Sharpsburg or Shelby soils of the uplands.

The profile of this soil is similar to that described as representative for the series, but the surface layer is about 18 inches thick and very dark brown to black. The loess mantle on the benches is only 4 to 8 feet thick in most places, and therefore the substratum consists partly of alluvial material in places where the loess is thinnest. The alluvial material is stratified. It is primarily loam, but it varies in texture and is fine sand in places.

Included with this soil in mapping were a few somewhat poorly drained areas of soils that have a grayish-brown subsoil and are similar to the Macksburg soils.

This soil is well suited to row crops, and most areas are in crops. Individual areas are small in most places, and the soil generally is managed with the adjoining soils.

Figure 16.—**Row crops grown on the contour on Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded.**

A few areas are subject to slight erosion. The organic-matter content is medium to high, and the soil has good tilth in most places. (Capability unit I–1; woodland suitability group 3)

Sharpsburg silty clay loam, benches, 2 to 5 percent slopes (ScB).—This soil is on high benches near major streams. Typically it is upslope from nearly level Sharpsburg soils on benches or from Nevin or Wiota soils, which are on second bottoms at slightly lower elevations (fig. 18). Steeper Sharpsburg and Shelby soils are upslope in the uplands.

The profile of this soil is similar to that described as representative for the series. The loess mantle on the benches is only 4 to 8 feet thick in most places, and the substratum consists partly of alluvial material in places where the loess is thinnest. The alluvial material is stratified and is mainly loam, but it varies in texture and is fine sand in places.

Included with this soil in mapping were small areas of nearly level Sharpsburg soils.

This soil is subject to erosion but is well suited to row crops if erosion is controlled. Individual areas of this soil are small in most places. Most areas are managed with the adjacent soils as cropland. The organic-matter content is medium to high, and tilth is good in most places. (Capability unit IIe–1; woodland suitability group 3)

Shelby Series

The Shelby series consists of deep, dark-colored, moderately well drained soils of the uplands that formed in glacial till. These soils are on side slopes where slopes are 9 to 25 percent. They are adjacent to and downslope from the Clarinda and Lamoni soils and are upslope from the Arbor, Colo, Olmitz, Zook, and other alluvial soils. They are in all parts of the county but are most extensive in the Southwestern part. The native vegetation was prairie grasses.

In a representative profile, the surface layer is about 15 inches thick. It is very dark gray loam in the upper part and very dark grayish-brown light clay loam in the lower part. The subsoil extends to a depth of about 72 inches. It is brown in the upper part, grades to dark yellowish brown, and is mixed yellowish brown and grayish brown at a depth of more than 64 inches. The subsoil is medium clay loam in the upper part and is light clay loam in the lower part. The substratum is mixed yellowish-brown and grayish-brown, calcareous clay loam.

The Shelby soils have high available water capacity and are moderately slow in permeability. They are typically medium acid in the surface layer unless limed and are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium. They are moderately fertile, are medium to very low in organic-matter content, and have a deep, favorable root zone.

Figure 17.—**This nearly level bench is occupied by Sharpsburg soils and is near Middle River.**

Some areas of Shelby soils are in crops. Runoff is rapid. Erosion is a severe hazard where vegetation is thin. Gullies form easily.

Representative profile of Shelby loam, 9 to 14 percent slopes, moderately eroded, 800 feet east and 105 feet north of the southwest corner of SW¼ sec. 3, T. 74 N., R. 29 W., on a straight slope of about 11 percent:

A1—0 to 11 inches, very dark gray (10YR 3/1) heavy loam; moderate, fine, granular structure; friable; very dark brown (10YR 2/2) when kneaded; slightly acid (pH 6.4); clear, smooth boundary.

A3—11 to 15 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, fine, granular structure and weak, fine, subangular blocky structure; friable; few, very dark gray organic coatings on ped exteriors; few ½-inch pebbles at a depth of 14 to 15 inches; slightly acid (pH 6.2); clear, smooth boundary.

B21—15 to 22 inches, brown (10YR 4/3) medium clay loam; few, very dark grayish-brown (10YR 3/2) ped faces; weak, fine and medium, subangular blocky structure; firm; few pebbles; medium acid (pH 5.7); clear, smooth boundary.

B22t—22 to 45 inches, dark yellowish-brown (10YR 4/4) medium clay loam; faces of peds brown (10YR 4/3); weak, medium, prismatic structure, breaking to moderate, fine and medium, subangular blocky structure; firm; thin, discontinuous, dark-brown (10YR 3/3) to brown (10YR 4/3) clay films; clay films nearly continuous on prism faces; few, clean sand grains on ped faces at depth of 24 to 26 inches; few, soft, iron oxide concretions; few pebbles and stones; medium acid to slightly acid (pH 5.6, increasing to 6.2 with depth); gradual, smooth boundary.

B23t—45 to 64 inches, dark yellowish-brown (10YR 4/4) medium to light clay loam; weak, medium, prismatic structure, breaking to weak to moderate, subangular blocky structure; firm; brown (10YR 4/3), discontinuous clay films; common, strong-brown (7.5YR 5/8) mottles; few, fine, dark, soft oxide concretions; few pebbles and stones; slightly acid (pH 6.4); gradual, smooth boundary.

B3—64 to 72 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) light clay loam; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, medium, prismatic structure; firm; few clay films; few ½-inch stones and pebbles; few, soft, dark oxide concretions; neutral (pH 7.2); clear, smooth boundary.

C—72 to 96 inches, mixed yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) clay loam; many, fine, distinct, strong-brown (7.5YR 5/8) mottles; few olive-gray (5Y 5/2) mottles in vertical seams; massive; firm; olive gray (5Y 5/2) and yellowish brown (10YR 5/4) at a depth of 92 to 96 inches; matrix calcareous; common stones and pebbles; mildly alkaline (pH 7.8).

The surface layer ranges from black to very dark gray in color and where not eroded, from 10 to 18 inches in thickness. It is dominantly loam but ranges to light clay loam. Where the surface layer is thinner, it contains slightly more clay. The subsoil ranges from 2½ to 6 feet in thickness and from brown to yellowish brown in color. In some places the lower part of the subsoil has gray, grayish-brown, olive-gray, or strong-brown mottles that vary widely in size and abundance. The subsoil ranges from light clay loam to heavy clay loam, but the upper 20 inches of the subsoil averages less than 35 percent clay. The substratum is yellowish brown to grayish brown and has distinct gray, olive-gray, or strong-brown

Figure 18.—**Cattle grazing in pasture on a Sharpsburg silty clay loam.**

mottling in places. Carbonates or lime concretions are in this layer at depths ranging from about 2½ to 6 feet.

Among Shelby soils, mapping unit SkE3 has a surface layer that is thinner and lighter colored than is within the defined range for the series.

The Shelby soils differ from the Gara and Lindley soils in having a thicker surface layer and in not having a subsurface layer. They also have slightly less clay in the subsoil than the Gara and Lindley soils. They are browner colored in the subsoil, better drained, and more permeable than the Lamoni soils.

Shelby loam, 9 to 14 percent slopes, moderately eroded (ShD2).—This soil is on side slopes directly downslope from the Lamoni and Sharpsburg soils. On many long slopes this soil extends as a band around heads of drainageways. Many hillside waterways are present. Areas range from 10 to 30 acres in size.

This soil has the profile described as representative for the series. In many places the surface layer is very dark grayish-brown loam to clay loam that is only about 3 to 7 inches thick.

Included with this soil in mapping were small areas of Arbor and Lamoni soils. Also included were small, severely eroded and slightly eroded areas. The more significant severely eroded areas are indicated on the soil map by the symbol for severely eroded spots. Near the base of some slopes or next to waterways, there are inclusions of a soil having a darker, thicker surface layer.

This Shelby soil is moderately suited to row crops if erosion is controlled. Most areas are cultivated, but small areas within areas of steeper Shelby soils are commonly in pasture. (Capability unit IIIe-1; woodland suitability group 4)

Shelby loam, 14 to 18 percent slopes (ShE).—This soil is on side slopes, on rounded ridgepoints, or on slopes that form bowllike areas around heads of drainageways in the steeper parts of the county. In some places it occupies the entire valley slopes between narrow ridges occupied by Sharpsburg soils and the Colo-Ely silty clay loams, which lie downslope along waterways. It is also adjacent to and downslope from the less steep Lamoni soils. The individual areas are small.

The profile of this soil is similar to the one described as representative for the series. The surface layer is about 8 to 12 inches thick in most places, but near the base of slopes, it is thicker due to deposition of friable, loamy material that has been washed down.

Included with this soil in mapping were small areas of the Arbor and Lamoni soils and some very small, severely eroded areas.

This soil is poorly suited to row crops. If erosion can be controlled, some areas are practical to manage with less sloping soils as cropland. Most areas are in pasture. Because of moderately steep slopes and the firm subsoil, water runs off rapidly if this soil is cultivated, and the surface layer erodes readily. (Capability unit IVe-1; woodland suitability group 4)

Shelby loam, 14 to 18 percent slopes, moderately eroded (ShE2).—This soil is on irregular side slopes and rounded points at the ends of ridges throughout the county. It commonly is downslope from and adjacent to the Lamoni or Sharpsburg soils and upslope from and adjacent to alluvial soils in drainageways. Individual areas range from 10 to 50 acres in size.

The profile of this soil is similar to that described as representative for the series, except that the surface layer is very dark grayish brown and only 3 to 8 inches thick. Parts of some areas where accumulation occurs at the base of slopes have a thicker surface layer.

Included with this soil in mapping were small areas of Lamoni soils. These spots of Lamoni soils are very narrow, but those that are significant and cause slight seepage are indicated on the soil map by a symbol for wet spots. Also included were small areas of Arbor soils and very narrow strips of alluvial soils near small drainageways.

Most areas are moderately eroded, but a few are severely eroded, and in these the subsoil is exposed. If these severely eroded areas are evident but are too small to be mapped separately, they are indicated on the soil map by the symbol for severely eroded spots.

Runoff is rapid because of moderately steep slopes, a thin surface layer, and a firm subsoil. Consequently, this soil erodes if vegetation is removed. It is better suited to pasture than to cultivated crops because of the hazard of erosion. (fig. 19). However, a large acreage is in small grain, row crops, or hay, for many areas lie adjacent to soils more suitable for crops. Even if erosion is controlled, this soil is poorly suited to row crops. (Capability unit IVe–1; woodland suitability group 4)

Shelby loam, 18 to 25 percent slopes, moderately eroded (ShF2).—This steep soil is mainly on side slopes and on sharply rounded ridges between waterways, many of which have noncrossable gullies. It also occurs on slopes that form bowllike areas around heads of large waterways. The slopes are very irregular, and this soil is intermingled with other Shelby soils having less steep slopes. This soil is adjacent to and downslope from the Lamoni or other Shelby soils and is upslope from the Arbor soils or alluvial soils along large drainageways or small streams.

The surface layer is very dark gray or very dark grayish-brown loam or light clay loam. It ranges from 3 to 10 inches in thickness and is thickest near small streams and drainageways. It averages about 5 or 6 inches in thickness.

Included with this soil in mapping were severely eroded areas and areas of less eroded Shelby soils. Severely eroded areas are shown on the soil map by the symbol for severely eroded spots. Also included were small areas of Gara soils near steep, wooded areas.

Figure 19.—Shelby soils used for pasture.

Nearly all of this soil is in permanent pasture, but a few small areas are in woodland. Because of steep slopes, use of this soil is limited and the hazard of erosion is very severe. The steep slopes and gullies make the use of equipment for pasture renovation hazardous. (Capability unit VIe–1; woodland suitability group 5 or 6)

Shelby soils, 14 to 18 percent slopes, severely eroded (SkE3).—These soils are on irregular side slopes and rounded points at the ends of ridges throughout the county. They commonly are downslope from and adjacent to the Lamoni or Sharpsburg soils and upslope from and adjacent to alluvial soils in drainageways. The most severely eroded areas are mainly on sharply rounded slopes between hillside waterways. Some areas are upslope from the Arbor soils. Most areas are small, but a few range up to 10 acres in size.

The profile of these soils has a thinner surface layer than the profile described as representative for the series. The original surface layer has nearly all been removed by erosion, and the present surface layer is loam or clay loam that is dark brown or very dark grayish brown on the surface.

Included with these soils in mapping were small areas of Lamoni soils and the less eroded Shelby soils.

These soils are suited to pasture or woodland. They are not suited to row crops. Runoff is rapid, and the hazard of erosion is very severe. Available plant nutrients are low, tilth is poor to very poor, and the organic-matter content is low. The waterways tend to gully easily from excess runoff. Many are uncrossable by machinery. (Capability unit VIe–1; woodland suitability group 4)

Shelby-Lamoni complex, 5 to 9 percent slopes, moderately eroded (SlC2).—This mapping unit is mostly on short, irregular side slopes and extended, narrow, sloping ridges. The Lamoni soils occupy about 50 percent of the total acreage, and Shelby soils make up nearly all the rest. Shelby soils commonly are on the lower part of the slope, and Lamoni soils are on the upper part. The complex occupies positions downslope from the Sharpsburg soils and upslope from the Shelby soils. In some areas of the county this complex occurs downslope from and adjacent to areas of the Clarinda soils.

The Shelby and Lamoni soils in this mapping unit have profiles similar to the ones described as representative for their respective series. The surface layer ranges from 3 to 10 inches in thickness and from loam to light clay loam in texture. Color ranges from black to very dark grayish brown.

Some areas have small inclusions of very poorly drained Clarinda soils.

This complex is moderately suited to row crops if erosion and wetness are controlled. It occurs in very small areas and is managed with other soils as cropland or pasture. There is seepage at the junction of these soils and more permeable soils upslope. Thus, the wetness appears as a band around the upper part of the slopes. Interceptor tile drains placed in the soils upslope help to reduce the wetness.

Crossable hillside waterways are common. The organic-matter content is low to medium, tilth is normally poor, and the surface layer is cloddy. (Capability unit IIIe–3; woodland suitability group 4)

Shelby-Lamoni complex, 9 to 14 percent slopes (SlD).—This complex is mainly on side slopes of uplands in all parts of the county. It consists of Shelby and Lamoni soils in about equal acreages. The Shelby soils are in the lower part of mapped areas, and the Lamoni soils are in the upper part. The complex is downslope from and adjacent to Clarinda or Sharpsburg soils and upslope from the steep Shelby soils. In some areas it extends around ridges and drainageways and has an irregular slope. Individual areas are small and narrow.

The Shelby and Lamoni soils have profiles similar to the ones described as representative for their respective series. The surface layer is black to very dark brown loam 10 to 14 inches thick.

Included in mapping were small bands of the very poorly drained Clarinda soils near the upper edge of mapped areas and well-drained Arbor soils near the base of slopes.

Most areas of this complex are now in pasture and are managed with steep Shelby soils. Removal of vegetation increases runoff and subjects the soils to serious erosion. Even if erosion is controlled, the soils are poorly suited to row crops. Some areas are wet and seepy near the upper boundary. Tile drains in the more permeable soils upslope aid in reducing wetness. (Capability unit IVe–2; woodland suitability group 4)

Shelby-Lamoni complex, 9 to 14 percent slopes, moderately eroded (SlD2).—This complex is on irregular side slopes in all parts of the county. It occurs mainly in small areas, but the areas range up to 40 acres in size. Shelby soils make up about 60 percent of the total acreage and are in the lower part of mapped areas; Lamoni soils make up nearly 40 percent of the acreage and are in the upper part. This complex commonly occupies positions downslope from the Clarinda or Sharpsburg soils, forming narrow bands adjacent to and upslope from the steep Shelby soils.

The profiles of the Shelby and Lamoni soils are similar to the ones described as representative for their respective series, but the surface layer is thinner. The surface layer is 3 to 7 inches thick, contains material from the subsoil, and is very dark grayish-brown to dark-brown loam or light clay loam.

Included with this complex in mapping were small areas of the Clarinda soils. Significant areas of the Clarinda soils and severely eroded areas are indicated on the soil map by symbols for gray clay spots and severely eroded spots.

The soils in this complex are suited to pasture, but some areas are managed with more suitable soils upslope as cropland. Erosion is the main hazard. Runoff is rapid because the thin surface layer does not absorb rainfall readily and permeability is slow in the Lamoni soils. Hillside waterways, many of them noncrossable by machinery, tend to gully. Some areas dry out slowly and are wet and seepy near the upper boundary. Even if erosion is controlled and wetness is reduced, this complex is poorly suited to row crops. (Capability unit IVe–2; woodland suitability group 4)

Shelby-Lamoni complex, 9 to 14 percent slopes, severely eroded (SlD3).—This complex is in very small areas on side slopes in all parts of the county. It consists about equally of Shelby soils, which are in the lower part of mapped areas, and Lamoni soils, which are in the upper part.

The profiles of the Shelby and Lamoni soils in this complex have a thinner surface layer than the representative profiles described for the series. Nearly all the original surface layer has been removed by erosion, and the remaining layer is less than 3 inches thick. The present surface layer is commonly dark-brown, firm clay loam but is loam in some less eroded areas. The subsoil is exposed in many places.

Included with this complex in mapping were small areas of the Clarinda soils and some small spots that are less than severely eroded.

The soils in this complex are not suited to row crops. They are suited to pasture. The surface layer has poor tilth, is cloddy, and is very low in organic-matter content. Both sheet and gully erosion are very serious hazards. (Capability unit VIe-2; woodland suitability group 4)

Shelby-Lamoni complex, 14 to 18 percent slopes, moderately eroded (SlE2).—This moderately steep complex is in all parts of the county on irregular side slopes. Shelby soils occupy about 60 percent of the acreage and are in the upper part of individual areas; Lamoni soils occupy nearly 40 percent and are in the lower part of the areas. The complex is downslope from the Sharpsburg soils and in some places upslope from steep Shelby soils. In many areas it occupies the entire side slope, and in these places it is upslope from small stream bottoms occupied by such soils as those in the Colo-Ely complex, 2 to 5 percent slopes.

The remaining part of the original surface layer ranges from 3 to 10 inches in thickness. The Lamoni part of the complex is commonly more eroded than the Shelby part in most areas. In places where slopes flatten out near the base of hillsides, the surface layer is darker and thicker than it is in other places.

Included with this complex in mapping were small areas of Clarinda soils. Also included were small areas of Arbor and Olmitz soils.

The soils in this complex are not suited to row crops, but they are suited to pasture. They contain many hillside waterways that gully badly, and many of these waterways are noncrossable by machinery. There is a serious hazard of erosion. Tilth is normally poor. The organic-matter content is low.

Most areas of these soils are managed as permanent pasture. Gullies need to be checked or stabilized and erosion controlled by a good cover of vegetation. (Capability unit VIe-2; woodland suitability group 4)

Shelby-Lamoni complex, 14 to 18 percent slopes, severely eroded (SlE3).—This complex is in very small areas. About 60 percent of it is Shelby soils, and about 40 percent is Lamoni soils. The complex commonly is adjacent to Sharpsburg soils upslope and occurs within or is adjacent to areas of less eroded Shelby-Lamoni complexes on side slopes. Most areas contain gullies, and in some places the complex makes up a small cove around a cutting gully on a hillside.

The Shelby and Lamoni soils of this mapping unit have profiles similar to the ones described as representative for their series, except that the surface layer is thinner. The present surface layer typically is dark-brown loam or clay loam and consists partly of subsoil material. In many places this layer is only about 3 inches thick.

The soils in this complex are not suited to row crops. The surface layer has very poor tilth and is cloddy. In places it cracks badly during dry weather. The very severe hazard of gully erosion limits use for pasture, and use for woodland and wildlife habitat is an alternative. In many areas it is difficult to use ordinary farm equipment in renovating pastures because of irregular slopes and gullying. (Capability unit VIIe-1; woodland suitability group 4)

Sloping Stony Land

Sloping stony land (0 to 18 percent slopes) (SoE) is on strongly sloping to moderately steep, high foot slopes below limestone ledges near Middle and North Rivers in the central part of the county. The individual areas range from 5 to 30 acres in size. This land type is adjacent to and downslope from Steep rock land and the Nordness soils, and it is upslope from the Ladoga soils on benches or other soils on second bottoms. Normally, it is moderately well drained. Loamy and silty material that supports vegetation is between the rocks.

This land type consists of limestone fragments that range from a few inches to 2 feet or more in diameter and are mixed with soil materials of loessial or glacial origin. In a few places it includes shaley materials. No distinct, uniform soil profile has been formed.

The surface layer ranges from very dark gray to very dark grayish brown. It is most commonly loam or silt loam but ranges to clay loam and silty clay loam. It averages about 8 inches in thickness. A finer textured, firmer subsoil is starting to develop in places where the upper 2 feet has fewer rock fragments and the silty or loamy mantle is the thickest. There is a wide range in the amount, size, and distribution of the rock fragments.

Permeability is moderate to moderately rapid. The available water capacity is medium to very low, depending on the amount of rock fragments. The favorable root zone commonly is shallow but ranges to deep within short distances. It is limited by the rock present.

This land type is not suited to row crops. Most areas are in pasture or woodland pasture. Runoff is rapid, because of the strong slopes.

Parts of some areas, where stone fragments are beneath the surface, can be mowed or renovated, but in many areas ordinary farm equipment is not used. These areas yield good pasture when rainfall is well distributed. Grass roots are shallow in places, but roots of woody plants can penetrate between the rock fragments. This land is suited to woodland or wildlife habitat. (Capability unit VIIe-3; woodland suitability group 1)

Sperry Series

The Sperry series consists of deep, moderately dark colored, very poorly drained soils that formed in loess in level or depressed areas on broad upland divides. These soils are associated with the Winterset and Macksburg soils in all parts of the county. The native vegetation was water-tolerant prairie grasses.

In a representative profile, the surface layer is very dark gray silt loam about 7 inches thick. It is grayish brown when dry. The distinct subsurface layer is dark-gray, friable silt loam that is light gray when dry. It is about 3 inches thick. The grayish subsoil extends to a depth of about 49 inches. The upper 5 inches is slightly darker than the subsurface layer and is silty clay loam. It is friable and is very dark gray when moist and light gray when dry. This part of the subsoil has no mottling. Most of the subsoil, to a depth of about 40 inches, is dark-gray and gray, firm silty clay. It contains yellowish-brown, brown, olive-brown, and strong-brown mottles that increase in size and abundance with depth. The lower 8 or 9 inches of the subsoil is firm, gray silty clay loam that has prominent, coarse, strong-brown mottles. The substratum is light-gray, friable silty clay loam that is highly mottled with strong brown.

The Sperry soils have high available water capacity. They are slow or very slow in permeability. Internal drainage is poor to very poor. Slow permeability causes water to stand in depressed areas for long periods after heavy rains. These soils are slightly acid or medium acid in the surface layer unless limed and are medium in organic-matter content. They are very low to low in available nitrogen and potassium and very low in available phosphorus.

Sperry soils are suited to crops if drained. Most areas are in crops and are managed with the adjacent Macksburg and Winterset soils. The major limitation to use for crops or pasture is wetness.

Representative profile of Sperry silt loam, 745 feet north and 170 feet east of the southwest corner of sec. 19, T. 74 N., R. 26 W., in a cultivated field on a level to slightly depressed upland ridgetop:

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam; grayish brown (10YR 5/2) when dry; cloddy, to weak, medium, granular structure; friable; few fine pores; slightly acid (pH 6.5); abrupt, smooth boundary.

A2—7 to 10 inches, dark-gray (10YR 4/1) silt loam; some very dark gray (10YR 3/1); light gray (10YR 6/1) when dry; weak, fine, platy structure, breaking to weak, fine, granular structure; friable; few fine pores; slightly acid (pH 6.5); clear, smooth boundary.

B1—10 to 15 inches, very dark gray to dark-gray (10YR 3/1 to 4/1) silty clay loam; light gray (10YR 6/1) when dry; weak, fine, subangular blocky structure; friable; common fine pores; medium acid (pH 6.0); clear, smooth boundary.

B21tg—15 to 22 inches, dark-gray (10YR 4/1) silty clay; common, fine, distinct, dark yellowish-brown (10YR 3/4 and 4/4) mottles; few, fine, distinct, yellowish-brown (10YR 5/6) mottles in lower part of horizon; thick, continuous clay films on ped faces; some very dark gray (10YR 3/1) coatings; moderate, fine, subangular blocky structure; firm; few oxides; few pores; medium acid (pH 6.0); gradual, smooth boundary.

B22tg—22 to 40 inches, gray (10YR 5/1) silty clay; common, medium, distinct, brown (7.5YR 4/4), strong-brown (7.5YR 5/6), yellowish-brown (10YR 5/6), and light olive-brown (2.5Y 5/4) mottles; weak, medium, prismatic structure, breaking to moderate, medium, subangular blocky structure; firm; thin, continuous clay films on ped faces; few oxides; few, dark oxide stains; common fine pores; neutral (pH 6.8); gradual, smooth boundary.

B3tg—40 to 49 inches, gray (10YR 5/1), heavy silty clay loam; common, coarse, prominent, strong-brown (7.5YR 5/6) mottles; weak, medium, prismatic structure; firm; thin, discontinuous clay flows on prism faces; common, coarse, black (10YR 2/1) oxide stains; neutral (pH 6.8); gradual, smooth boundary.

Cg—49 to 60 inches, light gray (10YR 6/1) silty clay loam; common, prominent, strong-brown (7.5YR 5/6) mottles; massive, but some vertical cleavage; friable; neutral (pH 6.8).

The surface layer ranges from black to very dark gray in color and from 6 to 12 inches in thickness. The subsurface layer is very dark gray to gray and is 2 to 8 inches thick. In most places the subsurface layer and upper part of the subsoil are much lighter gray when dry, but in some places they are barely discernible. The surface and subsurface layers range from silt loam to light silty clay loam. The subsoil ranges from 24 to 40 inches or more in thickness and from dark gray to light gray in color. There is a wide range in the size and abundance of brown mottles. The texture of the subsoil ranges from heavy silty clay loam to silty clay. The combined thickness of the surface and subsurface layers and the subsoil ranges from 40 to 60 inches. The light-gray silty clay loam substratum has a wide range in the size and number of strong-brown mottles.

Sperry soils differ from the Macksburg and Winterset soils in having a thinner surface layer, a distinct grayish subsurface layer, and a finer textured, more slowly permeable subsoil. Also, the Sperry soils are more poorly drained and are in nearly level or depressed positions.

Sperry silt loam (0 to 1 percent slopes) (Sp).—This soil is in flat or depressed areas on broad, nearly level upland divides between the major streams. It is adjacent to, and many small areas occur within, large areas of the nearly level Macksburg and Winterset soils.

Included with this soil in mapping were very small areas of the adjacent Macksburg and Winterset soils.

This soil is moderately suited to row crops if drained and is managed with the associated Macksburg and Winterset soils. It occurs in small areas ranging from 3 to 15 acres in size. Many areas less than 3 acres in size are indicated on the soil map by a spot symbol.

This soil is wet, and water ponds in the depressed areas after rains. Properly spaced tile drains correct this wetness in most places. In a few areas the subsoil is so fine textured that tile drains do not function well. (Capability unit IIIw-2; woodland suitability group 11)

Spillville Series

The Spillville series consists of deep, dark-colored, moderately well drained to somewhat poorly drained soils that formed in loamy alluvium on first bottoms. These soils occur in small areas on all major stream bottoms, but they are most common along Middle River and Clanton and Jones Creeks.

The Spillville soils are associated with the Colo, Kennebec, and Zook soils. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark gray loam about 39 inches thick. This is underlain, to a depth of about 53 inches, by very dark grayish-brown loam that is a transitional layer between the surface layer and the substratum. At a depth of about 53 inches there is a layer of dark grayish-brown, friable sandy loam.

The Spillville soils have high available water capacity and are moderate in permeability. They commonly are slightly acid in the surface layer unless limed, and they are low to medium in available nitrogen and medium to high in available phosphorus and potassium. Spillville soils that have a flaggy substratum are typically neutral in the surface layer unless limed. The organic-matter content ranges from medium to high. These soils commonly have a deep, favorable root zone, but in the soils having a flaggy substratum, this zone is only moderately deep.

These soils are mainly in crops. They are subject to flooding, and because they are in small areas intermingled with more poorly drained soils, inadequate drainage is a minor limitation. Excellent pasture is grown in some areas that are not accessible to machinery.

Representative profile of Spillville loam, 1,240 feet west and 100 feet north of the southeast corner of sec. 1, T. 74 N., R. 28 W., in a nearly level cultivated field:

Ap—0 to 9 inches, black (10YR 2/1) light loam; weak, fine, granular structure; friable; slightly acid (pH 6.5); clear, smooth boundary.

A11—9 to 17 inches, black (10YR 2/1) loam; weak, medium to fine, granular structure; friable; slightly acid (pH 6.3); gradual, smooth boundary.

A12—17 to 27 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral (pH 6.6); gradual, smooth boundary.

A13—27 to 39 inches, very dark gray (10YR 3/1) loam; weak, medium, subangular blocky structure; friable; few, fine, tubular pores; slightly acid (pH 6.0); gradual, smooth boundary.

AC—39 to 53 inches, very dark grayish-brown (10YR 3/2) loam; faces of peds very dark gray (10YR 3/1); weak, medium, subangular blocky structure; friable; few, fine, tubular pores; some clean sand grains on ped surfaces; slightly acid (pH 6.0); gradual, smooth boundary.

C—53 to 60 inches, dark grayish-brown (2.5Y 4/2) sandy loam; weak, coarse, blocky structure to massive; friable; few, fine, tubular pores; some clean sand grains; slightly acid (pH 6.2).

The surface layer ranges from black to very dark gray in color, from 30 to 40 inches in thickness, and from heavy sandy loam to light clay loam in texture. Brown and gray mottles are at a depth of more than 30 inches in a few places, but in most areas these soils are not mottled. The substratum ranges from very dark gray to dark grayish brown and from loam or sandy loam to light clay loam. The depth from the surface to the sandy loam substratum ranges from 36 to 60 inches.

Among Spillville soils, mapping unit Ss has a flaggy loam substratum between depths of 24 and 40 inches. This is outside the range defined for the series.

Spillville soils differ from Colo and Kennebec soils in being less clayey and having more sand in the profile. They are loamy, but the Colo and Kennebec soils are silty.

Spillville loam (0 to 2 percent slopes) (Sr).—This soil is on first bottoms and occurs in small areas near all the major streams and their tributaries. The larger areas are along Middle River and Jones and Clanton Creeks. This soil is in association with the Colo, Kennebec, and Zook soils. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of the Colo and Kennebec soils and some sandy areas in which the soil contains more sand than Spillville soils. Significant sandy areas are indicated on the soil map by the symbol for sand spots.

Most areas of this Spillville soil are in crops. It is commonly managed with adjacent soils. Some areas that have poor access for farm machinery are in pasture.

This soil is subject to flooding, and flood protection is needed in places. Its close association with poorly drained, less permeable soils on bottom land creates a minor drainage problem. Tiling and extension of surface drains are necessary in some places. If the wetness is corrected, this soil is well suited to crops. (Capability unit IIw-1; woodland suitability group 10)

Spillville loam, flaggy substratum (0 to 2 percent slopes) (Ss).—This soil is in narrow valleys consisting of first bottoms and low second bottoms in areas of the county that have limestone outcrops. It also occurs in some low, isolated areas on bottom lands along Middle and North Rivers. This soil is adjacent to the Colo and Kennebec soils on wider first bottoms. In some places on narrow bottoms, it is adjacent to Flaggy alluvial land.

The profile of this soil is similar to that described as representative for the Spillville series, but flaggy limestone occurs in large amounts below a depth of 24 to 36 inches (fig. 20). Very small fragments of limestone are present in the upper layers in places.

Included with this soil in mapping were small areas of Flaggy alluvial land and spots of very sandy deposition. Also included were a few areas where slopes are 2 to 5 percent.

This soil is well suited to row crops. Most areas are small, however, and are poorly accessible to machinery. Consequently, they are managed with adjacent soils as pasture.

This soil does not require lime and is easily tilled if accessible. Floodwaters recede so rapidly that droughtiness is the major concern in management of the soil for crops. (Capability unit IIs-1; woodland suitability group 2)

Steep Rock Land

Steep rock land (25 to 70 percent slopes) (StG) is dominated by limestone ledges and outcrops in association 4 (see fig. 9, p. 10). It is on low ledges near stream bottoms in the western part of the county and is higher on side slopes in the central part. It is downslope from the Gara and Lindley soils. Areas of this land are common along Middle River, along branches of North River, and along Cedar, Clanton, and Jones Creeks.

Figure 20.—Profile of Spillville loam, flaggy substratum.

No typical profile can be described for this land. The ledges of bedrock have little vegetation, but in many places they have crumbled to form very steep slopes. Loamy, marly, black soil has formed between fragments, and woody vegetation and some grasses have become established on these slopes.

About three-fourths of this mapping unit has slopes ranging from 25 to 40 percent, and one-fourth has slopes of 40 to 70 percent. Steep rock land is in areas that are large but vary considerably in size. Vertical ledges of bare rock are in the steeper areas.

Slopes are broken, and there are rocky ravines and steep foot slopes below outcrops. Downslope, this land is intermingled with soils derived from shale. It includes many smaller, very steep areas of soils formed in sandstone, shale, and glacial materials. Major soils included are the Clanton, Gosport, Hixton, and Nordness soils.

This land is suited to woodland and wildlife habitat. It is too shallow and droughty for good pasture. Tree roots can penetrate into the crevices, and fair growth occurs in areas where bare rock is not exposed. Other than woodland and wildlife products, there is little direct agricultural value. Many quarries are located in these areas.

The major limitations are slow absorption of moisture and droughtiness, and the major hazard is very rapid runoff. During heavy rains, limestone fragments up to 2 feet in size are loosened and washed down by water and gravity to form rocky, detrimental deposits on more valuable alluvial soils.

In addition to limestone products, these areas have scenic and recreation values. The city park at Winterset and Pammel State Park occupy large areas of this land. (Capability unit VIIe-3; woodland suitability group 1)

Vesser Series

The Vesser series consists of deep, dark, poorly drained soils that formed in alluvium on second bottoms. These level to gently sloping soils occur in small areas near all the major streams, but they occupy only a small total acreage.

Vesser soils are associated with Bremer, Wabash, Zook, or other alluvial soils. The native vegetation was trees, or trees and prairie grasses.

In a representative profile, the surface layer is black to very dark brown and very dark gray silt loam about 13 inches thick. Next is a dark-gray silt loam subsurface layer that is about 14 inches thick and contains a few, dark-brown mottles. The subsoil extends to a depth of 52 inches. It is dark-gray, firm light to medium silty clay loam that contains dark-brown and strong-brown mottles, which are larger and more numerous in the lower part. The substratum is lower in clay content than the subsoil and normally is gray silt loam that has a high content of fine sand. It is highly mottled with brown and grayish brown. The detailed profile that is given as representative for the series is not described to a depth great enough to show the substratum.

The Vesser soils have high available water capacity and are moderate in permeability. These soils are medium to low in organic-matter content and are medium acid in the surface layer unless limed. They are low in available nitrogen and phosphorus and are medium in available potassium.

Vesser soils are mainly used as cropland. In most places they are managed with adjacent soils. They receive some deposition from adjacent slopes, but the major concern of management is the improvement of drainage. Higher areas are not flooded, and other areas are flooded only infrequently. If these soils are drained, they have few limitations for crops or pasture.

Representative profile of Vesser silt loam, 2 to 5 percent slopes, 520 feet west and 170 feet south of the northeast corner of the SW¼NE¼ sec. 12, T. 74 N., R. 28 W., in a cultivated field on a slope of 3 percent:

Ap—0 to 7 inches, very dark brown to very dark gray (10YR 2/2 to 3/1) silt loam; cloddy, breaking to weak, fine, granular structure; friable; medium acid (pH 5.7); clear, smooth boundary.

A1—7 to 13 inches, black (10YR 2/1) silt loam; very dark brown (10YR 2/2) when crushed; weak, medium, platy structure, breaking to weak, fine, granular structure; friable; medium acid (pH 5.6); clear, smooth boundary.

A2—13 to 27 inches, dark-gray (10YR 4/1) silt loam; common, fine, distinct, dark-brown (7.5YR 3/2) mottles; dark grayish brown (10YR 4/2) when crushed; weak, fine and medium, platy structure; friable; common, very dark brown oxides at depth of 22 inches; strongly acid (pH 5.1); gradual, smooth boundary.

B1g—27 to 30 inches, dark-gray to gray (10YR 4/1 to 5/1) light silty clay loam; common, fine, distinct, dark-brown (7.5YR 3/2) mottles; weak, medium, subangular blocky structure; friable; common, fine, tubular pores; common, grainy, gray coatings; common, very dark brown oxides; strongly acid (pH 5.1); gradual, smooth boundary.

B21tg—30 to 35 inches, dark-gray (10YR 4/1) silty clay loam; few, fine, distinct, dark-brown (7.5YR 3/2) mottles; moderate, medium, prismatic structure, breaking to moderate, fine to very fine, subangular blocky structure; firm; few, fine, tubular pores; thin, discontinuous, very dark gray (10YR 3/1) clay films on prism and ped faces; common, very dark brown concretions; strongly acid (pH 5.1); gradual, smooth boundary.

B22tg—35 to 40 inches, dark-gray (10YR 4/1) silty clay loam; common, medium, distinct, dark-brown (7.5YR 3/2) mottles; moderate, medium, prismatic structure, breaking to weak to moderate, fine, subangular blocky structure; firm; few, fine, tubular pores; common, thin, discontinuous, very dark gray (10YR 3/1) clay films; few, very dark brown concretions of an oxide; strongly acid (pH 5.1); gradual, smooth boundary.

B3tg—40 to 52 inches, very dark gray (10YR 3/1) and dark-gray (10YR 4/1) silty clay loam; common, medium, prominent, dark-brown to strong-brown (7.5YR to 5/6) mottles; weak, medium, prismatic structure; friable; medium acid (pH 5.6).

The surface layer ranges from 10 to 18 inches in thickness and from black to very dark grayish brown in color. The subsurface layer ranges from about 10 to 20 inches in thickness and from dark gray to gray in color. Some of this layer is mixed with dark grayish brown. The combined thickness of the surface and subsurface layers ranges from 24 to 32 inches. The subsoil ranges from very dark gray to gray and has a wide range in size and amount of brown mottling. The substratum occurs at a depth of 40 to 60 inches. It is more sandy than the subsoil, and in some areas it is stratified with sand. It is typically gray, but there is a very wide range in gray and brown colors and in texture. A few areas are underlain by limestone bedrock at a depth of more than 4 feet.

The Vesser soils differ from Bremer soils in having a thinner surface layer and a thick, grayish subsurface layer. They are more poorly drained than the Nevin soils, and they have a subsurface layer, which is missing in Nevin soils.

Vesser silt loam, 0 to 2 percent slopes (VeA).—This nearly level soil is on low second bottoms. It is most commonly associated with the Bremer, Wabash, and Zook soils.

The profile of this soil differs from that described as representative for the series in commonly having a darker, somewhat thinner surface layer that ranges to light silty clay loam. The subsurface layer is also thinner, ranging from 6 to 8 inches in thickness, and the subsoil is grayer and finer textured in some places. In many areas the subsoil is slightly more clayey, less permeable, and more poorly drained.

Included with this soil in mapping were small areas of adjacent and associated soils. Also included were small areas of soils that have a silty clay subsoil; these soils are more slowly permeable and are more difficult to drain than the Vesser soils.

The only limitation to use of this soil is wetness. The soil is suited to crops if it is adequately drained. Most areas are in crops and are managed with adjacent soils. In low level positions, water stands for moderately long periods. The soil is flooded only when floodwaters are very high. Its tilth is good, except in places that have standing water. This soil is well suited to row crops if tile drains and surface drains are adequate to reduce wetness. (Capability unit IIw–1; woodland suitability group 11)

Vesser silt loam, 2 to 5 percent slopes (VeB).—This soil is on high second bottoms. It is commonly adjacent to and downslope from the Ladoga soils at lower positions on the same bench. In some places it is adjacent to and upslope from soils on first bottoms. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of the adjacent Ladoga soils and small areas of nearly level Vesser soils.

This soil is well suited to row crops if wetness is controlled. It occurs in small areas, and most areas are managed with the adjacent soils as cropland. Soil tilth is easy to maintain. Surface drainage is adequate, and the only limitation is poor subsoil drainage. In a few areas runoff from soils upslope needs to be diverted from this soil. (Capability unit IIw–1; woodland suitability group 11)

Wabash Series

The Wabash series consists of deep, dark-colored, very poorly drained soils that formed in clayey alluvium on wide river bottoms. These soils are on all the major stream bottoms of the county.

The Wabash soils are commonly adjacent to the Zook soils, which are nearer to the stream. In some areas they are adjacent to the Bremer soils, which are in somewhat higher positions between the Wabash soils and the better drained soils near the stream. Wabash soils are subject to flooding during periods of high streamflow and to receiving runoff from adjacent slopes. The native vegetation was water-tolerant grasses.

In a representative profile, the surface layer is black and very dark gray silty clay about 27 inches thick. The subsoil is very dark gray and dark gray heavy silty clay about 25 inches thick. The lower part contains dark yellowish-brown and brown mottles. The substratum typically contains less clay than the subsoil. The detailed profile that is described as representative for the series is not described to a depth great enough to show the substratum.

The Wabash soils have moderate available water capacity, absorb water slowly, and are very slow in permeability. They are neutral to strongly acid, and they are high in organic-matter content. Wabash soils are low to medium in available nitrogen and are medium to high in available phosphorus and potassium. The silty clay to clay subsoil and excess water limit development of roots. Because there are few drainageways, surface drainage is poor. Ponding occurs in some places.

Wabash soils are used mainly for crops, but use for crops or pasture is limited by the silty clay or clay subsoil that hinders drainage. Most areas are in crops, but there is a wide range in yield. This depends on the extent to which the soils can be drained and the frequency and intensity of rainfall or flooding.

Representative profile of Wabash silty clay, 1,775 feet south and 2,180 feet east of the northwest corner of sec. 32, T. 76 N., R. 26 W., in a cultivated field on a nearly level first bottom:

A11—0 to 12 inches, black (10YR 2/1) silty clay; gray (10YR 5/1) when dry; weak, medium, prismatic structure, breaking to weak, medium, subangular blocky structure; firm; medium acid (pH 5.5); gradual, smooth boundary.

A12—12 to 27 inches, very dark gray (10YR 3/1) heavy silty clay; gray (10YR 5/1) when dry; weak, medium, subangular blocky structure; very firm; medium acid (pH 5.7); gradual, smooth boundary.

Bg—27 to 52 inches, dark-gray (10YR 4/1) and very dark gray (N 3/0) heavy silty clay; few, fine, distinct, dark yellowish-brown (10YR 3/4) and dark-brown (7.5YR 3/2) mottles; weak, coarse, subangular blocky structure, to massive; very firm; medium acid (pH 6.0).

The surface layer ranges from about 26 to 36 inches in thickness. The subsoil ranges from 24 to 48 inches in thickness and from very dark gray to gray in color. It is heavy silty clay to clay. In some places the subsoil has brown mottles that vary widely in size and abundance. Sand particles are in the lower part of the subsoil in some areas. The substratum occurs at a depth of about 4 to 6 feet. It has a very wide range in color and texture. Thin layers of sand occur in some places.

The Wabash soils differ from Zook soils in having a more clayey, less permeable subsoil. They are less permeable, have a more clayey subsoil, and are more poorly drained than the Bremer soils.

Wabash silty clay (0 to 2 percent slopes) (Wa).—This soil is in small, widely separated areas on wide major stream bottoms in nearly level or depressed slack-water areas adjacent to foot slopes. It is adjacent to Wabash silty clay loam and the Zook soils nearer the stream. In some areas it is adjacent to the Bremer soils on low benches or second bottoms. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of adjacent soils and Alluvial land.

This soil is suited to both crops and pasture but very poor drainage, serious flooding, and ponding are limitations. The surface layer is in poor tilth. It dries out very slowly, is very hard and cloddy when dry, and forms wide cracks that extend into the subsoil. Power requirements to till this soil are high.

Water stands for long periods in some areas where surface drainage is not adequate. About one-third of the acreage of this soil is in crops and is managed with more suitable adjacent soils. Adequate surface drainage is needed if row crops are grown. Woodland and wildlife habitat are suitable uses because of the limitations for crops and pasture. (Capability unit IIIw-3; woodland suitability group 11)

Wabash silty clay loam (0 to 2 percent slopes) (Wb).—This nearly level soil is on bottom lands in the broad valleys of the major streams and their larger tributaries. It is in slack-water areas of bottoms near the foot slopes of uplands. It is adjacent to the Wabash and Zook silty clay soils. Some areas are adjacent to the Bremer soils on low benches or second bottoms. This soil is more extensive than Wabash silty clay and occurs in larger areas that vary widely in size and shape.

The profile of this soil is similar to that described as representative for the series, but the surface layer, to a depth of about 1½ feet, is silty clay loam.

This soil is more suitable for row crops than Wabash silty clay. In dry springs and with well-distributed rainfall, some areas are in fair tilth.

Most areas are in crops but some are in pasture. Most areas are managed with adjacent soils. Surface drainage is needed where row crops are grown. Natural drainage is very poor. The soil dries slowly, and tillage is difficult. Power requirements to till this soil are high. Some small spots are marshy and idle. (Capability unit IIIw-3; woodland suitability group 11)

Winterset Series

The Winterset series consists of deep, dark-colored, poorly drained soils that formed in loess on broad upland ridgetops. These soils are on the wide divides between the major streams in the nearly level, central part of the ridgetop.

The Winterset soils are mostly in the west-central and northwestern parts of the county, but they are in small areas on all major divides in the county. These soils are adjacent to the Macksburg soils near the slope break, and in many places they are in association with small areas of the Sperry soils. The native vegetation was water-tolerant prairie grasses.

In a representative profile, the surface layer is black silty clay loam about 19 inches thick. The upper part of the subsoil is firm, very dark gray silty clay. The middle part, between depths of 25 and 32 inches, is dark grayish-brown, firm light silty clay. Yellowish-brown and olive-brown mottles are present, and the number and size of mottles increase with depth. The lower part of the subsoil, below a depth of 32 inches, is grayish-brown and yellowish-brown silty clay loam. The substratum also is silty clay loam, but it is olive gray, is less firm than the subsoil, and has larger, more prominent, brown mottles. The detailed profile that is described as representative for the series is not described to a depth great enough to show the substratum.

The Winterset soils have high available water capacity and moderately slow to slow permeability. Runoff is slow, but the surface layers absorb water readily, and drainage is normally adequate. Winterset soils are medium acid in the surface layer unless limed, and they are high in organic-matter content. They are low to medium in available nitrogen and phosphorus and are medium in available potassium.

Because these soils are poorly drained, drainage improvement is a management requirement. After they are drained, they have a deep, favorable root zone.

The Winterest soils are used for crops where drainage is adequate. Nearly all the acreage is in crops.

Representative profile of Winterset silty clay loam, 483 feet west and 336 feet south of the northeast corner of sec. 6, T. 75 N., R. 28 W., in a nearly level cultivated field:

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; weak, medium, subangular blocky structure; firm; neutral (pH 6.9); clear, smooth boundary.

A1—7 to 19 inches, black (10YR 2/1) light to medium silty clay loam; moderate, fine, granular structure, grading to moderate, fine, subangular blocky structure with depth; friable; few, fine, hard oxides; medium acid (pH 6.0); gradual, smooth boundary.

B21t—19 to 25 inches, very dark gray (10YR 3/1) light silty clay; common, fine, faint, dark grayish-brown (2.5Y 4/2) to olive-brown (2.5Y 4/4) mottles; moderate, very fine, subangular blocky structure; firm; few, fine, hard oxide concretions; medium acid (pH 6.0); gradual, smooth boundary.

B22tg—25 to 32 inches, dark grayish-brown (10YR 4/2) light silty clay; faces of peds very dark gray (10YR 3/1); common, fine, faint, olive-brown (2.5Y 4/4) mottles and common, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, medium, prismatic structure, breaking to moderate, very fine, subangular blocky structure; firm; thin, discontinuous clay films; many, fine, hard oxides at depth of 27 inches and below; slightly acid (pH 6.2); gradual, smooth boundary.

B23tg—32 to 39 inches, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/4) heavy silty clay loam; faces of peds dark gray (5Y 4/1); common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; firm; thin, discontinuous, very dark gray (10YR 3/1) clay films on prisms and ped faces; many, fine oxides; medium acid (pH 5.8); gradual, smooth boundary.

B3tg—39 to 58 inches, olive-gray (5Y 5/2) medium silty clay loam; ped coatings of dark gray (5Y 4/1) and some very dark gray (10YR 3/1); common, fine, prominent, yellowish-brown (10YR 5/6) mottles and common, fine, distinct, olive-brown (2.5Y 4/4) mottles; moderate, medium, prismatic structure; friable; thin, discontinuous clay films; slightly acid (pH 6.3).

The surface layer ranges from 15 to 22 inches in thickness and is light to medium silty clay loam in texture. The subsoil is commonly heavy silty clay loam but includes a 10- to 15-inch layer of silty clay. There is an increase in clay content in the subsoil to a depth of 2 to 2½ feet, but below that the clay content decreases with depth. The subsoil ranges from about 24 to 48 inches in thickness. The substratum has a wide range in gray color and in the amount of brown mottling. It is less clayey than the subsoil, ranging from light silty clay loam to silt loam.

Winterset soils have a grayer subsoil, are more poorly drained, and occur in broader areas than the Macksburg soils. They have a darker colored, thicker surface layer and a more permeable subsoil than the Sperry soils, and they lack the grayish subsurface layer of the Sperry soils.

Winterset silty clay loam (0 to 2 percent slopes) (Wc).—This nearly level soil is on high, broad divides in all parts of the county. It is adjacent to the Macksburg soils near the slope break of divides and to the Sperry soils that are in depressed areas. In a few places in the southeastern part of the county it is adjacent to the Clearfield and Nira soils.

Included with this soil in mapping were small areas of Macksburg and Sperry soils. Small inclusions of the Sperry soil that are significant to management are indicated on the soil map by the symbol for Sperry soil. Also included, in the southeastern part of the county, were 100 acres of a soil that has a higher clay content in the subsoil than this Winterset soil.

This soil is well suited to row crops if adequately drained. It is commonly managed with the adjacent Macksburg soils. The major concern of management is wetness caused by poor drainage. This soil warms up and dries out somewhat more slowly than the Macksburg or Sharpsburg soils. (Capability unit IIw-2; woodland suitability group 11)

Wiota Series

The Wiota series consists of deep, dark-colored, moderately well drained soils that formed in silty alluvium on second bottoms or low stream benches. These soils are level to gently sloping and have slopes that range from 0 to 5 percent.

Wiota soils are on somewhat lower stream benches than the Givin, Ladoga, and Sharpsburg soils on benches. They are not subject to flooding. Some areas slope gradually to adjacent first bottoms, and others have short steep escarpments. The native vegetation is prairie grasses.

In a representative profile, the surface layer is very dark brown, very dark grayish-brown, and dark-brown silt loam about 18 inches thick. The subsoil extends to a depth of about 50 inches and contains the most clay at a depth of about 3 feet. The subsoil is brown in the upper part, grades to yellowish brown in the lower part, and contains some grayish-brown and yellowish-brown mottles. It is silt loam in the upper part and silty clay loam at a depth of about 29 inches. The substratum is similar to the subsoil in color and content of clay, but below a depth of 4 to 6 feet it contains more sand. In some areas it has thin layers of stratified sand. The substratum commonly is yellowish-brown silty clay loam mottled with gray, but it has a wide range in texture, color, and thickness of stratified layers. The detailed profile that is described as representative for the series is not described to a depth great enough to show the substratum.

The Wiota soils have high available water capacity. They generally are moderate in permeability but are moderately slow in places. They are high in organic-matter content. Wiota soils are low in available nitrogen, medium in available phosphorus, and low to medium in available potassium. They have a deep, favorable root zone.

Wiota soils are productive and easy to cultivate. They are used for crops, and most areas are managed with adjacent soils. They have few limitations. Surface drainage is good, and the surface layer takes in water readily. In gently sloping areas runoff is medium, and these areas are subject to erosion.

Representative profile of Wiota silt loam, 0 to 2 percent slopes, 680 feet north and 95 feet west of the southeast corner of SE¼NE¼ sec. 36, T. 76 N., R. 27 W., on a nearly level, cultivated low stream bench:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; neutral (pH 6.8); clear, smooth boundary.

A1—7 to 13 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) silt loam; grayish brown (10YR 5/2) when dry; weak, fine to very fine, granular structure; friable; neutral (pH 6.6); gradual, smooth boundary.

A3—13 to 18 inches, dark-brown (10YR 3/3) heavy silt loam; faces of peds very dark grayish brown (10YR 3/2); weak, fine, subangular blocky structure; friable; medium acid (pH 5.6); gradual, smooth boundary.

B1t—18 to 29 inches, brown (10YR 4/3) heavy silt loam; faces of peds dark grayish brown (10YR 4/2); few, fine, faint, dark yellowish-brown (10YR 4/4) mottles in the lower part; weak, medium, prismatic structure, breaking to moderate, fine, subangular blocky structure; friable; thin, discontinuous clay films; few fine pores; medium acid (pH 5.6); gradual, smooth boundary.

B2t—29 to 37 inches, dark yellowish-brown (10YR 4/4) medium to heavy silty clay loam; faces of peds brown (10YR 4/3); few, medium, faint, grayish-brown (10YR 5/2) mottles and few, fine, distinct, brown (7.5YR 5/4) mottles; moderate, medium, prismatic structure, breaking to moderate, medium, subangular blocky structure; firm; nearly continuous, dark grayish-brown (10YR 4/2) clay films on prism faces; thin, continuous clay films on blocky faces; black (10YR 2/1) and very dark gray (10YR 3/1) organic stains in pores and on ped faces; few, dark oxides; medium acid (pH 5.6); gradual, smooth boundary.

B3t—37 to 50 inches, yellowish-brown (10YR 5/4) silty clay loam; faces of peds brown (10YR 4/3); common, fine, distinct, grayish-brown (10YR 5/2) mottles; moderate, medium, prismatic structure, breaking to moderate, medium, subangular blocky structure; firm; thin, discontinuous clay films; black (10YR 2/1) and very dark gray (10YR 3/1) organic stains in pores and on ped faces; grainy gray coatings on vertical faces; medium acid (pH 5.8).

The surface layer ranges from nearly black to very dark grayish brown in color and from 16 to 24 inches in thickness. Its texture is silt loam in most places, but commonly is light silty clay loam. The subsoil ranges from 24 to 36 inches in thickness. The texture centers on medium silty clay loam, but thin layers range from heavy silt loam to heavy silty clay loam. In a few areas where stratified alluvium is present, the lower part of the subsoil is loam, light clay loam, or silty clay loam that contains enough sand to have a gritty feel. The brown subsoil has a few gray mottles in some areas. The substratum varies considerably in texture and in color, depending on the amount of stratification.

The Wiota soils differ from the Nevin soils in being better drained and having a browner, less mottled subsoil. They differ from Sharpsburg soils on benches because they have a slightly higher sand content, contain less clay in the subsoil, and are more permeable.

Wiota silt loam, 0 to 2 percent slopes (WoA).—This nearly level soil is the most extensive of the Wiota series. It is on high, moderately well drained second bottoms near all the major streams of the county. It is adjacent to the Nevin and gently sloping Wiota soils, and in some areas it is adjacent to Givin, Ladoga, and Sharpsburg soils on benches. In other places it is adjacent to the Colo and Kennebec soils on first bottoms, occurring in small elevated areas within the first bottoms or joined by a short, steep escarpment. It contains few waterways, but surface drainage is adequate in most places. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of the somewhat poorly drained Nevin soils, small areas of other adjacent soils, and short, steep escarpments. Major escarpments are indicated on the soil map by the symbol for escarpments.

This soil is well suited to row crops. It is fertile and in good to excellent tilth. It dries out quickly after rains and can be tilled sooner than more poorly drained soils. There is a wide range in size of individual areas, and most are managed as cropland with other soils on first and second

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bottoms. This soil has no limitations, but small included areas of more poorly drained soils require drainage. (Capability unit I–1; woodland suitability group 3)

Wiota silt loam, 2 to 5 percent slopes (WoB).—This gently sloping soil is on benches near the major streams and wider tributaries in the county. Most areas of this soil are adjacent to and downslope from the nearly level Givin and Wiota soils and are adjacent to the Colo and Kennebec soils, which are near the main streams. In a few areas this soil is adjacent to the Caleb-Mystic soils. It contains short drainageways, and slopes are irregular in many areas.

The profile of this soil is similar to that described as representative for the series, but the surface layer is not as thick.

Included with this soil in mapping were small areas of nearly level Wiota soils and somewhat poorly drained Nevin soils. Also included were a few very sandy spots in some areas. These are indicated on the soil map by the symbol for sand spots.

This soil is well suited to row crops if erosion is controlled. The surface layer absorbs rainfall readily, but runoff is moderate and is an erosion hazard. Most areas are in crops and are managed with adjacent soils.

If erosion is controlled, this soil has few limitations. The organic-matter content is high, good tilth is easy to maintain, and the soil dries quickly after rains. (Capability unit IIe–1; woodland suitability group 3)

Zook Series

The Zook series consists of deep, dark-colored, poorly drained soils that formed in moderately fine textured alluvium on river bottoms. These soils are level to gently sloping. They are the most common soils on narrow stream bottoms, and they occur in all parts of the county.

On the wider bottom lands, Zook soils are adjacent to the more friable Colo and Kennebec soils, which are closer to the stream. In many places they are between these soils and the finer textured, more poorly drained Wabash soils. On the very wide bottoms that have bench or second-bottom soils, some areas of Zook soils are adjacent to the Bremer, Nevin, and Wiota soils. At the base of side slopes, some areas of Zook soils are adjacent to and downslope from the Ely and Olmitz soils. The native vegetation was water-tolerant prairie grasses.

In a representative profile, the surface layer is black and very dark gray silty clay loam about 29 inches thick. The subsoil also is very dark gray silty clay loam, but it is slightly finer textured than the surface layer and is firm. Dark grayish-brown mottling occurs at a depth of about 30 inches, and the mottles increase in abundance and size with depth. The substratum is dark-gray or very dark gray, firm silty clay loam. It is highly mottled with brown and has about the same clay content as the subsoil. The detailed profile that is given as representative for the series is not described to a depth great enough to show the substratum.

The Zook soils have high available water capacity and are slow in permeability. Their wetness is a result of flooding, a high water table, and slow permeability. These soils are high in organic-matter content. They are typically slightly acid unless limed. They are low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium. These soils have a deep, favorable root zone, but in undrained areas growth of roots is limited by the high water table.

The Zook soils are used mainly for crops. The chief concern of management is providing adequate drainage. Individual areas range up to 40 acres in size, but normally they are managed with other soils. Zook soils are flooded occasionally, but most areas are wet because of a high water table and slow runoff.

Representative profile of Zook silty clay loam, 0 to 2 percent slopes, 480 feet north and 200 feet west of the southeast corner of sec. 33, T. 77 N., R. 27 W., in a nearly level, cultivated field on a wide river bottom:

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; weak, medium, angular blocky structure, breaking to weak, medium, granular structure; friable; neutral (pH 6.8); clear, smooth boundary.

A1—7 to 18 inches, black (10YR 2/1) silty clay loam; dark gray (10YR 4/1) when dry; moderate, very fine, subangular blocky structure; friable; neutral (pH 6.8); gradual, smooth boundary.

A3—18 to 29 inches, very dark gray (10YR 3/1) heavy silty clay loam; gray (10YR 5/1) when dry; moderate, fine and very fine, subangular blocky structure; firm; slightly acid (pH 6.4); gradual, smooth boundary.

B2—29 to 38 inches, very dark gray (10YR 3/1) heavy silty clay loam; few, fine, faint, dark grayish-brown (10YR 4/2) mottles; gray (10YR 5/1) when dry; moderate, fine, angular blocky structure; firm; few, fine, hard concretions of an oxide; slightly acid (pH 6.3); gradual, smooth boundary.

B3—38 to 60 inches, very dark gray (10YR 3/1) heavy silty clay loam; common, fine, faint, dark grayish-brown (10YR 4/2) and dark-brown (10YR 3/3) mottles; gray (10YR 6/1) when dry; weak, fine, angular blocky structure; firm; medium acid (pH 5.9).

The surface layer is normally black, but it ranges to very dark gray in color and from 24 to 36 inches in thickness. In areas on some narrow bottoms that are frequently flooded, a thin layer of fine sand or silt has been deposited on the surface. The subsoil ranges from silty clay loam to light silty clay in texture and from a few inches to 30 inches in thickness. There is a wide range in the amount of dark grayish-brown mottling. The substratum varies widely in texture and color, and in some areas there are strata of sand at a depth of more than 4 feet.

The Zook soils differ from the Colo and Kennebec soils in having a higher clay content and in being more poorly drained. Zook soils are similar to Wabash soils in color, but the Wabash soils are more clayey and more poorly drained.

Zook silty clay loam, 0 to 2 percent slopes (ZoA).—This soil is on first bottoms along all the major streams and their tributaries in the county. It occurs in association with the Colo, Kennebec, Spillville, and Wabash soils.

This soil has the profile described as representative for the series. In some areas, where flooding is most frequent, there are silty and fine sand deposits mixed in the surface layer.

Individual areas of this soil are irregular in shape and include small areas of adjacent and associated soils. Significant areas of included soils that are like the Spillville soils but have a sandy surface layer are indicated on the soil map by the symbol for sand spots. Inclusions of Wabash soils and very small ponded areas are indicated on the soil map by the symbol for wet spots.

This soil is well suited to row crops if wetness is controlled. Soil tilth is normally good unless the soil is plowed when wet. Most areas are managed as cropland with adjacent soils on bottom lands, but some small areas that are less accessible remain in pasture or woodland.

The major concern of management is improving drainage. This soil dries out slowly but can be satisfactorily drained in most places. Surface drains are needed in a few, small, ponded areas. (Capability unit IIw-1; woodland suitability group 11)

Zook silty clay loam, 2 to 5 percent slopes (ZoB).—This gently sloping soil is in small areas on alluvial fans at the foot of side drainageways and on foot slopes that parallel the base of glacial-till side slopes on uplands. It is upslope and adjacent to the nearly level Zook soil or other clayey, poorly drained, alluvial soils, such as the Wabash soils. In some places it is downslope from and adjacent to the Olmitz soils.

The profile of this soil is similar to that described as representative for the series in color and thickness of soil layers. It is, however, more variable in texture. The alluvial material in which this soil formed was washed from adjacent side slopes. There is more fine sand in this soil than is typical for the series and there is a wide range in amount. It ranges from silty clay loam to silty clay loam with enough sand to give a gritty feel and to clay loam in places.

Included with this soil in mapping were areas of Ely and Olmitz soils, which are in similar positions, and small areas of other adjacent soils. Also included were small spots of sandy and light-colored, silty deposits.

This soil is well suited to row crops if drained. It occupies small areas that are managed with adjacent soils. The major concern of management is wetness caused by a high water table and by runoff of surface water from steeper side slopes. Erosion and deposition tend to be about equal, but some areas need diversions to protect this soil from detrimental deposition and gullying in the waterways. (Capability unit IIw-1; woodland suitability group 11)

Use and Management of the Soils

This section describes the system of capability classification used by the Soil Conservation Service and discusses the use and management of groups of soils. These groups are called capability units. Some of the characteristics of soils in the units that affect their management are discussed. Also in this section is a table showing predicted yields of the major crops for the soils in the county. In addition, there are discussions of the use of the soils for woodland, wildlife, and recreation, and the section describes the engineering uses of soils. Most of the information on engineering is presented in tables in which properties that affect engineering are estimated and the soils are interpreted according to their suitability for engineering uses.

Use of the Soils for Crops and Pasture

In Madison County about 189,000 acres, or about 52 percent of the total acreage, is used for cropland. About 144,000 acres, or about 40 percent, is used for pasture. This includes many areas that are partly wooded.

Corn, soybeans, oats, legumes, and legume-grass hay are the major crops grown. Minor crops include sudangrass and other grasses that are used for pasture, as well as sorghums that are mainly harvested for silage.

Most pastures in the county consist of permanent bluegrass. In some of these, the stand has been renovated and plants such as birdsfoot trefoil have been introduced. Grass-legume mixture such as alfalfa-bromegrass are also grown.

Regular and grassed-backslope terraces are used to control erosion on the Ladoga, Sharpsburg, Shelby, and similar soils that are subject to sheet erosion and gullying.

Drain tile is used to reduce wetness in such soils as the Colo, Winterset, and Zook. Interceptor tile is used to reduce wetness in such soils as the Clarinda, Clearfield, and Lamoni. In places, surface drains are used to remove excess water from the Wabash and similar soils, which are fine textured and in which tile drains do not work well.

Gully control structures, farm ponds, and grassed waterways are used to control gullying in watercourses. In a few places levees are used to protect bottom lands from flooding, but this is not a common practice.

Capability Groups of Soils

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

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

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

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

- Class I. Soils have few limitations that restrict their use.
- Class II. Soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV. Soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V. Soils are not likely to erode but have other limitations, impractical to remove, that

limit their use largely to pasture, range, woodland, or wildlife habitat.

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

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

Class VIII. Soils and landforms have limitations that reduce their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (None in Madison 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 that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States, but not in Madison County, shows that the chief limitation is climate that is too cold or too dry.

In Class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-2 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.

In the following pages the capability units in Madison County are described and suggestions for the use and management of the soils are given. The names of soil series represented are named in the description of each capability unit, but this does not mean that all of the soils of a given series are 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

This unit consists of deep, nearly level, moderately well drained soils on uplands and benches. These soils are in the Sharpsburg and Wiota series. Their surface layer is silt loam to silty clay loam, and their subsoil is silty clay loam.

All the soils in this unit have high available water capacity and moderate to moderately slow permeability. These soils absorb much of the rain that falls in normal amounts and hold much of this moisture available for plants. These soils have properties favorable for deep root development. The organic-matter content is medium to high. Unless limed, these soils are medium acid to slightly acid in the surface layer. They are low to medium in available nitrogen and phosphorus and range from low to high in available potassium.

The soils in this unit warm up quickly in spring and can be worked soon after rain. Tilth is good in most places and is easy to maintain. The soils are not subject to significant erosion. Surface drainage is adequate, even though the soils are nearly level.

Nearly all areas of these soils are used for row crops. Smaller areas are generally farmed with the more sloping or somewhat poorly drained adjacent areas. Corn and soybeans are the major crops, but small grains and hay or pasture also are grown.

These soils are well suited to row crops if fertility and soil tilth are maintained and if weeds and insects are controlled. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or weeds or insects become problems.

CAPABILITY UNIT I-2

This unit consists of deep, nearly level, somewhat poorly drained soils on uplands and benches. These soils are in the Givin, Macksburg, and Nevin series. Their surface layer is silt loam to silty clay loam, and their subsoil is firm silty clay loam.

All the soils in this unit have high available water capacity and moderately slow permeability. These soils absorb much of the rain that falls in normal amounts and hold most of this moisture available for plants. They have properties favorable for deep root development. The organic-matter content is medium to high. Unless limed, these soils range from slightly to strongly acid in the surface layer. They are low to medium in available nitrogen and range from very low to high in available phosphorus and from low to high in available potassium.

These soils are normally in good tilth and are not subject to erosion. They are somewhat poorly drained, and some areas remain somewhat wet during periods of high rainfall. This wetness is more evident along small drainageways in these soils.

Nearly all areas of these soils are used for cultivated crops. Most areas are managed with adjacent soils. Corn and soybeans are the principal crops, but small grains and hay or pasture also are grown.

These soils are well suited to row crops and can be farmed intensively if fertility and soil tilth are maintained and if weeds and insects are controlled. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or if weeds or insects become problems.

CAPABILITY UNIT I-3

This unit consists of deep, nearly level, moderately well drained soils on bottom lands. These soils are in the Kennebec and Nodaway series. These soils are silt loam throughout, but the Nodaway soil is stratified and is lighter colored and more variable in texture below the surface layer than the Kennebec soil.

The soils in this unit have high available water capacity and moderate permeability. These soils absorb much of the rain that falls in normal amounts and hold most of it available for plants. These soils are medium to moderately low in organic-matter content and slightly acid to neutral throughout. They are low in available nitrogen, range from low to high in available phosphorus, and are medium to high in available potassium.

These soils can generally be tilled earlier in the spring than the wetter associated soils. Flooding may occur in periods of high rainfall, or in spring when heavy snowfall melts. However, most flooding occurs in spring before crops are planted. The soils are sloping enough to prevent ponding, but erosion is not a hazard.

Most areas of these soils are used for cultivated crops, but some are in pasture or woodland. Some areas are of sufficient size to be farmed separately, but most are managed with adjacent soils. Corn and soybeans are the major crops, but grain sorghum, small grains, and hay also are grown.

These soils are well suited to intensive row cropping if fertility and soil tilth are maintained and if weeds and insects are controlled. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or if weeds or insects become problems. A few areas may need lime, and all areas need additions of fertilizer if the cropping system consists mostly of row crops.

Some areas need protection from flooding. Old bayous can be filled and stream channels straightened to reduce flooding in some places. Areas at the base of slopes can be protected from runoff by the use of diversion terraces.

CAPABILITY UNIT IIe-1

This unit consists of gently sloping, chiefly moderately well drained and somewhat poorly drained soils on uplands and benches. These soils are in the Ladoga, Macksburg, Nevin, Sharpsburg, and Wiota series. All the soils have a surface layer of silt loam or silty clay loam and a subsoil of silty clay loam that has moderate to moderately slow permeability. Some of the soils are moderately eroded.

The soils in this unit have high available water capacity, and their organic-matter content is medium to high. These soils absorb most of the rain that falls in normal amounts and have properties favorable for root development. Unless limed, they are slightly acid to strongly acid in the surface layer. These soils are low to medium in available nitrogen, very low to medium in available phosphorus, and low to high in available potassium.

These soils are well suited to row crops but are subject to some sheet erosion because of slope. They dry quickly in spring and after rains and are easily kept in good tilth.

Nearly all areas of these soils are used for cultivated crops. Corn and soybeans are the main crops, but small grain, hay, or pasture also are grown. Many areas of these soils are large enough to be farmed separately but are irregular in shape. They are generally managed with small areas of nearly level or moderately sloping adjoining soils.

Runoff of surface water is medium, and erosion control is of greal importance. If terraced, the soils in this unit can safely be used frequently for row crops. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or weeds or insects become problems.

Some areas of these soils are difficult to terrace because slopes are irregular, and contour tillage, along with less intensive use of row crops, is more practical. Soils in this unit commonly stay in good tilth if crop residue is returned, but the moderately eroded soils benefit from extra additions of fertilizer.

CAPABILITY UNIT IIe-2

This unit consists mainly of deep, gently sloping, moderately well drained soils on low foot slopes or alluvial fans. These soils are in the Judson, Martinsburg, and Olmitz series. Their surface layer is loam, silt loam, or light silty clay loam, and their subsoil is clay loam to silty clay loam.

All the soils in this unit have high available water capacity and, in most places, moderate permeability. These soils absorb much of the rain that falls in normal amounts. They have properties favorable for good root development. The organic-matter content is medium to high. The surface layer is slightly acid to neutral in some areas of the Judson soils but ranges to strongly acid in the Martinsburg soils. These soils are low to medium in available nitrogen, low in available phosphorus, and medium to high in available potassium.

The soils in this unit warm up early in the spring and dry out quickly after rains. They are normally in very good tilth. Erosion is a slight problem, but there is some deposition from the steeper soils just upslope. These deposits are less fertile and lower in organic-matter content than the original surface layer. A new seeding may be lost if these deposits make it necessary to replant. Wetness is not a limitation in most places, because these soils are sufficiently sloping, but some small areas bordering poorly drained soils need tile drains.

These soils are well suited to row crops and other crops grown in the county. Most areas of these soils are small, but they vary in size. If practical, some are managed with the steeper adjacent soils upslope and are used for hay or pasture. Other areas are row cropped intensively with soils that are downslope on bottom lands.

Diversion terraces are used to intercept the runoff from the steeper soils upslope and to reduce the deposition on these soils. Contour tillage reduces runoff and erosion. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or weeds or insects become problems. Under normal conditions tilth is easily maintained by returning crop residue.

CAPABILITY UNIT IIe-3

This unit consists of deep, gently sloping, moderately well drained soils on uplands and benches. These soils are in the Clinton series. Their surface and subsurface layers both are silt loam, and their subsurface layer is light colored. Their subsoil is silty clay loam and moderately slow in permeability.

Runoff is medium, and the soils have high available water capacity. These soils have properties favorable for good root development. They are moderately low to low in organic-matter content. Unless limed, these soils are medium to strongly acid in the surface layer. They are low to very low in available nitrogen, very low to medium in available phosphorus, and low to medium in available potassium.

The soils in this unit warm up quickly in the spring and can be worked soon after rain. Tilth is poor in some areas but is not difficult to maintain in most places. The soils are subject to sheet erosion and tend to crust after rains.

These soils are limited by erosion but are well suited to row crops if erosion is controlled. About half of the acreage is in cultivation and is generally farmed with adjacent, moderately sloping soils downslope. Corn is the main row crop, but soybeans, small grain, and hay or pasture also are grown. Other areas are in pasture.

Controlling erosion is the major concern in the management of these soils. The use of winter cover crops and manure and the return of all crop residue improve soil tilth and increase the naturally low organic-matter content. Terraces and contour tillage are commonly used to control erosion. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or if weeds or insects become problems.

Many areas of these soils need lime. Natural fertility is somewhat low, and additions of fertilizers are beneficial, especially to row crops.

CAPABILITY UNIT IIw-1

This unit consists of deep, level to gently sloping, chiefly poorly drained to somewhat poorly drained soils on bottom lands, low foot slopes, and benches. These soils are in the Bremer, Colo, Ely, Spillville, Vesser, and Zook series. The Ely and Spillville soils are somewhat poorly drained to moderately well drained. Spillville soils are in this unit because of wetness caused by flooding, and the Ely soils are subject to runoff from adjacent slopes and have inclusions of wetter soils. Most of the soils in this unit have a thick silty clay loam surface layer, but the Spillville soils are loam throughout, and the Vesser soils have a silt loam surface layer. The subsoil is mostly silty clay loam.

All of the soils in this unit are high in organic-matter content. Unless limed, most of them are slightly acid to medium acid in the surface layer. These soils are low to medium in available nitrogen, very low to high in available phosphorus, and low to high in available potassium.

These soils are wet because of flooding, a high water table, or both. They dry out slowly in the spring and must be worked later than the better drained soils on bottom lands associated with this group. Tilth is generally good if wetness is controlled but the soils become cloddy if worked when wet. These soils have high available water capacity, but the excessive wetness can restrict plant growth and root development unless the soils are drained.

These soils are well suited to row crops, though they require artificial drainage or protection from flooding. Most areas of these soils are large enough to be managed separately. Areas of the Colo-Ely silty clay loams that are quite narrow and adjoin steep side slopes are generally not in crops.

Where drainage is adequate, corn and soybeans are the major crops. Some areas are managed without artificial drainage, but the risk of crop loss is greater than in drained areas. Small grains and hay or pasture also are grown. A meadow crop or a green-manure crop can be grown if soil tilth becomes poor or weeds or insects become problems.

Except for the Vesser soils, the soils in this group are flooded at times and receive damaging sediments. The Bremer soils are less subject to flooding than most of the other soils in this unit. Reseeding or replanting of crops may be necessary. Erosion is not a hazard, except on the Ely soils in the unit, but active gullies or stream channels may form. Runoff water from steeper soils upslope collects on the soils in this unit during heavy rains or drains across them before entering a stream or river.

Tile drains work well in these soils and are commonly used to provide drainage. Outlets are normally not difficult to locate. Grassed waterways are used in some areas to remove excess surface water. Excess runoff from adjacent slopes is controlled in some areas by diversion terraces at the base of upland slopes. The Ely soils benefit from contour tillage if row crops are grown. Fall plowing is practical if wetness delays planting in the spring.

CAPABILITY UNIT IIw-2

The only soil in this unit is Winterset silty clay loam. This soil is on uplands and is deep, nearly level, and poorly drained. It has a thick surface layer of silty clay loam. The subsoil has moderately slow to slow permeability. This soil is poorly drained because the surface runoff is slow and the water table is high during periods of high rainfall.

This soil has high available water capacity, but adequate artificial drainage is needed to provide proper aeration and a deep root zone for plants. This soil is high in organic-matter content. Unless limed, it is typically medium acid in the surface layer. It is commonly low to medium in available nitrogen, low to medium in available phosphorus, and medium in available potassium.

This soil warms up more slowly than the better drained soils on uplands. It cannot be cultivated as soon after rains because natural drainage is poor. This soil becomes puddled if worked when wet and becomes cloddy when dry. Generally, however, it is in good tilth.

This soil is well suited to row crops if it is drained. Erosion is not a hazard. In years of high rainfall, poor drainage and slow runoff may delay planting and cause crops to mature late. Almost all the acreage is in row crops and has some form of artificial drainage. Many areas are large enough to be farmed separately, but some are managed with the better drained adjacent soils. Corn and soybeans are the main crops, and grain sorghums, small grains, and hay also are grown.

Providing adequate drainage and maintaining good soil tilth are the major concerns of management. A meadow crop or a green-manure crop can be grown if tilth becomes poor or if weeds or insects become a problem. Tile drains work well in this soil. In some areas it is difficult to provide suitable outlets because of the width of broad, nearly level ridgetops on which the soil occurs.

CAPABILITY UNIT IIs-1

Spillville loam, flaggy substratum, is the only soil in this unit. It is a nearly level, moderately well drained to somewhat poorly drained soil on bottom lands, and it is moderately deep to fragmented limestone. The surface layer is friable loam that absorbs water readily. Fragments of limestone occur at depths of 2 to 3 feet and are more plentiful with increasing depth.

This soil has medium available water capacity and a favorable root zone to a depth of about 3 feet. The organic-matter content is medium to moderately high. This soil is typically neutral in the surface layer and does not need lime. It is low to medium in available nitrogen and is medium to high in available phosphorus and potassium.

This soil is well suited to row crops. It is also well suited to small grains and hay or pasture. Occasional flooding occurs on this soil, and sediments make reseeding or replanting necessary in some years. The soil is subject to some gullying or channeling. Floodwaters recede rapidly, and droughtiness is a greater limitation than wetness. The fragmented limestone tends to permit subsurface water to drain away readily, and it causes the soil to be somewhat droughty in years of low rainfall. The fragments are near the surface in a few places but seldom interfere with cultivation.

The areas vary in size, but most of them are small. Many areas are managed separately. Others are used as pasture with steeper adjoining soils. The principal crops are corn, soybeans, and meadow legumes or grasses.

Soil tilth is generally maintained by returning crop residue. If tilth becomes poor or if weeds or insects become problems, a meadow crop or a green-manure crop can be grown. Some small drainageways can be shaped and seeded to prevent gullying.

CAPABILITY UNIT IIIe-1

This unit consists of deep, moderately sloping and strongly sloping soils on uplands and foot slopes that are mostly moderately well drained and well aerated. These soils are in the Arbor, Caleb, Ladoga, Nira, Olmitz, Sharpsburg, and Shelby series. Their surface layer is light silty clay loam, loam, or silt loam, and their subsoil is silty clay loam or clay loam that has moderate to moderately slow permeability. Runoff is medium to rapid. Soils in the unit are slightly or moderately eroded, depending on past use and management. The Olmitz soil in this unit is well drained to moderately well drained.

All the soils in this unit have moderate to high available water capacity, and they have properties favorable for deep root development. These soils are average in fertility, low to high in organic-matter content, low to medium in available nitrogen, low to medium in available phosphorus, and high to low in available potassium. Unless limed, they are medium acid to slightly acid in the surface layer.

Tilth is good in most places, but it may be poor in small, severely eroded areas where the subsoil is exposed. In these areas the surface layer is hard and cloddy when dry. These soils are subject to erosion unless protected by vegetation or soil-conserving practices. The use of winter cover crops, fertilizer, and crop residue increases the organic-matter content, improves tilth, and helps control erosion.

Most areas of the soils in this unit are used for crops. Corn, soybeans, small grains, and hay are grown. The soils also are well suited to pasture, trees, or wildlife habitat if it is more practical to manage them with soils having greater limitations.

If these soils are protected from erosion by terraces, they are moderately suited to row crops. If only contouring is used to check soil losses, more years of meadow are needed. Grassed waterways are needed in many places.

Spreading barnyard manure and returning crop residue are especially beneficial for the eroded soils in this unit. Many areas need lime. Additions of fertilizers are needed when row crops are grown, although corn following a good crop of legumes may not need a large amount of nitrogen.

CAPABILIY UNIT IIIe-2

This unit consists of moderately sloping and strongly sloping, moderately well drained soils on uplands and high benches. These soils are in the Clinton series. Their surface and subsurface layers are silt loam, and their subsurface layer is light colored. Their subsoil is firm silty clay loam. Some of the soils are moderately eroded.

The soils in this unit have high available water capacity and moderately slow permeability. They are well aerated and have a deep, favorable root zone. These soils are below average in fertility. They are low to very low in organic-matter content, low to very low in available nitrogen, very low to medium in available phosphorus, and low to medium in available potassium. Unless limed, they are medium acid to strongly acid in the surface layer.

These soils are moderately suited to row crops if erosion is controlled; they also are suited to small grains, alfalfa, pasture grasses, and trees. Areas of these soils are irregular in size and shape, and most areas are managed with other soils as cropland or pasture, depending on the use of the adjacent soil. In some places soils of this unit are in woodland.

Runoff is rapid, and erosion is a severe hazard if these soils are cultivated. In eroded areas tilth is poor and the soil is somewhat cloddy when dry. The use of winter cover crops, manure, and crop residue increases the absorption rate and slows runoff, increases the organic-matter content, improves tilth, and helps control erosion.

These soils are moderately suited to row crops if mechanical practices are used for controlling erosion and grassed waterways are maintained to prevent gullying. Meadow crops are needed if contouring is the only erosion control measure. Additions of fertilizers are beneficial if row crops are grown. This is especially important on these soils because of the low natural fertility.

CAPABILITY UNIT IIIe-3

This unit consists of deep, moderately well drained and somewhat poorly drained, moderately sloping soils on upland side slopes. These soils are in the Gara and Lamoni series and a Shelby-Lamoni complex. Their surface layer is light clay loam or loam, and their subsoil is firm heavy clay loam to light clay.

The soils in this unit have high available water capacity and moderately slow to slow permeability. Runoff is rapid if the subsoil is saturated. These soils are medium to low in organic-matter content. Unless limed, they are slightly acid to strongly acid in the surface layer. They are commonly low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium.

The soils in this unit are used for the crops commonly grown in the county. Areas of these soils are small and are managed with other soils as cropland or pasture. In eroded areas, tilth is poor and the surface layer is very hard and cloddy when dry.

The major concerns of management are controlling erosion and maintaining fertility and good tilth. In some places the slowly permeable subsoil of the Lamoni soils causes seepy conditions in adjacent areas upslope and the water seeps over the Lamoni soils and causes wetness.

If erosion is controlled, the soils in this unit are moderately well suited to row crops. The Lamoni soils are not well adapted to terracing, because of seepiness and a firm, moderately fine textured subsoil that is difficult to cultivate. Contour tillage is commonly used for erosion control. Terraces are used on some soils upslope or downslope that are better suited to terrace construction.

The use of manure, cover crops, and crop residue improves tilth and helps to control weeds and maintain organic-matter content. Grassed waterways are maintained to prevent gullying from rapid runoff. Many areas of these soils need lime. Additions of fertilizers are needed when row crops are grown, and they are especially important because the natural fertility of the soils is not high.

CAPABILITY UNIT IIIw-1

This unit consists of deep, moderately sloping, poorly drained soils on uplands. These soils are in the Clearfield series. Their surface layer and subsoil are silty clay loam. At a depth of 3 to 6 feet, there is very firm, very slowly permeable, dark-gray clay. Some areas of these soils are moderately eroded.

The subsoil becomes quickly saturated as water movement is slowed by the more nearly impervious underlying material and this results in seepiness and wetness during periods of normal or above-average rainfall. These soils are poorly aerated and are moderately slow in permeability. These soils have high organic-matter content. Unless limed, they are slightly acid in the surface layer. They are low to medium in available nitrogen, low in available phosphorus, and low to medium in available potassium.

These soils are fertile and well suited to row crops if wetness is corrected. Tilth is good in most places. Corn and soybeans are the main crops, but small grains, hay, and pasture also are grown. Undrained areas are suited to hay and pasture.

These soils are commonly managed with adjacent, gently sloping and moderately sloping soils on side slopes. Interceptor tile placed just above the clayey underlying material is used to correct the seepiness and wetness.

Soils in this unit are subject to moderate erosion because of slope. If tile drains and erosion control practices are used, the soils are moderately suited to row crops. Grassed waterways are needed in many places to control gullying.

CAPABILITY UNIT IIIw-2

Sperry silt loam is the only soil in this unit. It is a deep, very poorly drained, nearly level to depressional soil on broad upland divides. The surface layer is silt loam, and there is a thin, distinct, dark-gray, silty subsurface layer. The subsoil is firm silty clay or heavy silty clay loam.

This soil has high available water capacity and slow to very slow permeability. This soil is moderately fertile and is high in organic-matter content. It generally has low to very low available nitrogen and potassium and very low available phosphorus. Unless limed, it is slightly acid or medium acid in the surface layer.

This soil dries out slowly, and water ponds and stands for long periods after heavy rains. Good tilth is difficult to maintain.

Individual areas are mostly small and are managed as cropland with other level, better drained soils on ridgetops. If drained, this soil is moderately suited to row crops. It is moderately well suited to small grains and meadow crops. Meadow crops or a green-manure crop can be grown if tilth becomes poor or weeds or insects become problems.

Properly spaced drain tile is generally satisfactory, but some areas dry out slowly even after tile is installed. The use of manure and crop residues improves tilth and regularly supplies organic matter.

CAPABILITY UNIT IIIw-3

This unit consists of nearly level, very poorly drained soils that have a clayey subsoil and are on bottom lands. These soils are in the Wabash series. The surface layer is heavy silty clay loam or silty clay that dries out very slowly and normally is cloddy and very hard when dry. Large cracks form during extended dry periods. The subsoil is very firm, compact, very slowly permeable silty clay or clay.

These soils have moderate available water capacity, but a fluctuating water table and the clayey subsoil restricts root development. The soils are fertile and high in organic-matter content, but it is difficult to prepare a good seedbed. Power requirements to till these soils are high. These soils are variable in reaction and range from slightly acid to strongly acid throughout. They are low to medium in available nitrogen and medium to high in available phosphorus and potassium.

These soils are poorly suited to crops that must be planted early in the spring. Fall plowing and the return of crop residue improve soil tilth. There is a wide range in size and shape of individual areas of these soils, but most are large.

Many large areas of these soils are managed separately. Others are managed with better drained adjacent soils and are mostly in crops. If good surface drainage is provided to prevent water from standing for long periods, these soils are moderately suited to row crops. Corn and soybeans are the principal crops grown. Some areas are subject to flooding. Tile drainage does not work well in these soils.

CAPABILITY UNIT IIIw-4

Only Alluvial land is in this unit. This land type consists of alluvial soils on first bottoms that are subject to yearly flooding.

This land has a wide range in color, texture, drainage, and permeability. It occurs near the stream channels and receives sandy and silty deposition from flooding. Permeability ranges from moderately rapid to moderately slow. The surface layer is neutral to slightly acid, and there is a wide range in fertility.

Alluvial land is poorly suited to crops because there is a considerable risk of flooding. As water recedes, small meandering channels provide surface drainage and the surface layer dries quickly. This land does not need tile drains in most places. Soil tilth is normally good and is easily maintained.

Most of the acreage is in trees and other woody vegetation, but some small areas are in crops or pasture. Where trees have been cleared, row crops are grown most of the time. In areas managed as woodland, selective cutting and thinning improve yield and value of woodland products. Mowing weeds and brush improves pasture.

CAPABILITY UNIT IVe-1

This unit consists of deep, moderately well drained, moderately steep soils on upland side slopes. These soils are in the Ladoga and Shelby series. Their surface layer is loam and silt loam, and their subsoil is firm clay loam or silty clay loam.

The soils in this unit have high available water capacity and moderately slow permeability. Runoff is rapid because of moderately steep slopes. Unless limed, these soils are typically medium acid to strongly acid in the surface layer. They have properties favorable for good root development. The organic-matter content is low to medium. These soils are low in available nitrogen, low to very low in phosphorus, and low to medium in potassium.

Tilth is moderately good in most places. These soils are subject to erosion and gullying. In areas of more serious erosion, the surface layer is sticky when wet and becomes hard and cloddy when dry. Small stones and pebbles are on the surface in some areas.

In most places the soils in this unit are in crops or in pasture. They are better suited to small grains, meadow crops, or permanent pasture than to row crops. Some areas are suited to trees or wildlife habitat.

Erosion is a severe hazard if row crops are grown. Semipermanent hay or pasture is a good use for these soils. A corn crop can be grown on the contour when stands of legumes and grasses need reseeding. Terrace construction is difficult in many places because of the moderately steep, irregular slopes.

CAPABILITY UNIT IVe-2

This unit consists of deep, strongly sloping, moderately well drained to somewhat poorly drained soils on uplands and side slopes of high benches. These soils are in the Gara, Lamoni, and Mystic series, the Shelby-Lamoni complex, and the Caleb-Mystic loams. The surface layer of these soils is loam or clay loam that is friable in most places. In some eroded areas, however, material from the subsoil has been mixed with the surface layer through plowing, and in these areas the present surface layer is sticky when wet and hard when dry. The subsoil ranges from heavy clay loam to clay.

All the soils in this unit have high to moderate available water capacity and moderate to slow permeability. Runoff is rapid in most places, erosion is a serious hazard, and gullies form easily. In most of the soils the movement of air and water is somewhat restricted. When the Lamoni soils are saturated, narrow seepy areas occur upslope in the more permeable loess-derived soils. The soils in this unit have a deep root zone, but root penetration is restricted in the subsoil of some of the soils, especially the Lamoni soils.

Natural fertility is low, and tilth is poor in most areas. The organic-matter content is low to medium. Unless limed, these soils are medium acid to strongly acid. They are mostly low in available nitrogen, low to very low in available phosphorus, and low to medium in available potassium.

Most areas of these soils are used for crops. Row crops, small grains, and grasses and legumes for hay and pasture are grown. Contour tillage is a common practice, and grassed waterways are used to prevent gullying. Terracing is practical in some areas, but the subsoil of these soils is mostly moderately fine textured and dense, and it requires very good management to restore productivity in the terrace channels.

These soils are poorly suited to row crops, even if erosion is controlled. Semipermanent hay or pasture is a suitable use. A year of row crops can be grown on the contour if stands of grasses and legumes need reseeding. Some small areas are managed with better suited soils. Others are more practical to manage with less suitable soils as pasture or woodland.

CAPABILITY UNIT IVe-3

This unit consists of deep and moderately deep, strongly sloping, moderately well drained soils on the upper part of side slopes and at the ends of ridges. These soils are in the Dunbarton, Keswick, and Lindley series. The surface layer is thin and is silt loam to loam. The subsoil ranges from heavy clay loam to clay and is firm or very firm.

The soils in this unit have high available water capacity, except for the Dunbarton soils, which have low to medium available water capacity. These soils are moderately slow to slow in permeability. Root development is restricted in some of the soils because of texture or periods of saturation. The organic-matter content is low to very low. Unless limed, these soils are medium acid to very strongly acid in the surface layer. They are low to very low in available phosphorus and low to medium in available potassium. Surface runoff is rapid.

Areas of these soils are small, and most of them are managed with steeper soils as permanent pasture or woodland. Some areas can be used for semipermanent hay or pasture and for a row crop grown on the contour when stands of grasses and legumes need reseeding. Some existing permanent pastures can be renovated and planted to more productive pasture plants. Fencing out livestock and using good management help to increase the productivity of many areas presently in woodland.

CAPABILITY UNIT IVw-1

This unit consists of deep, moderately sloping, very poorly drained soils on uplands near heads of drainageways. These soils are in the Clarinda series. Their surface layer is silty clay loam that, in most places, is friable and absorbs water well. In eroded areas, however, the surface layer is somewhat firm and runoff is more rapid. The subsoil is very firm, gray clay.

These soils have moderate available water capacity and very slow permeability. They are very poorly aerated. These soils remain wet and saturated for long periods. They are so impermeable that they cause seepy areas to occur at their boundary with the more permeable soils upslope. These seep waters move downslope and increase the wetness in the Clarinda soils.

These soils are low in natural fertility and medium to high in organic-matter content. Unless limed, they are slightly acid to medium acid in the surface layer. They are low in available nitrogen and phosphorus and are low to medium in available potassium.

Areas of these soils are small, irregular in shape, and managed with other soils as cropland or pasture. Many small areas, within areas of cultivated soils, are left idle.

These soils are poorly suited to row crops and are only moderately suited to hay and pasture because of the difficulty in overcoming the severe wetness. If the wetness is not too serious, a row crop can be grown when stands of hay or pasture become poor and need reseeding. The soils generally are so wet that alfalfa does not do well. Other legumes more tolerant to wetness are better adapted to the wettest areas.

Tile drains are not effective in these soils. In some areas interceptor tile placed in the more permeable soils upslope hastens drying, allows more timely tillage, and promotes the growth of more suitable grasses. If cultivated, these soils are subject to erosion. Terraces are not desirable, because the fine-textured subsoil is exposed in terrace channels and is very difficult to vegetate. Terraces should be built in soils above or below these soils.

CAPABILITY UNIT Vw-1

This unit consists of alluvial soils that have a wide range in texture, color, drainage, and permeability. It is made up of Alluvial land, channeled, and Flaggy alluvial land, and soils of the Colo, Ely, Martinsburg, and Nodaway series.

Most areas of these soils occur along small, stabilized, intermittent streams and their branches that form in the uplands. The soils are channeled and, in most places, are subject to frequent flooding. Flaggy alluvial land has many limestone fragments on the surface and in the soil profile.

Some areas of these soils occur along the major streams and tributaries. These areas are more nearly level and have more meandering stream channels and surface drains. The Nodaway soils and Alluvial land are mostly in these areas.

Along the major streams and tributaries, the surface layer is typically coarser textured than it is on narrower stream bottoms or drainageways. It ranges from silt loam to sandy loam or loamy sand.

The major limitations to use of the soils near larger streams are longer periods of flooding, streambank cutting, ponding or water standing in depressed areas, and detrimental deposition of sandy material.

Most areas along small intermittent streams and branching waterways are used for pasture. Other areas near larger streams are in trees and brush. A few small parts of these areas are managed as cropland with adjacent soils.

The soils in this unit are not suited to crops, because they are channeled, stony, or subject to flooding. Some areas have been made suitable for crops by straightening the streams, filling and shaping the channels, clearing trees and brush, and improving drainage. Reclaimed areas are managed with adjacent soils that are more suitable for cultivation.

CAPABILITY UNIT VIe-1

This unit consists of deep, steep and moderately steep, moderately well drained soils on upland side slopes. These soils are moderately or severely eroded and are in the Shelby series. In most places their surface layer is loam to light clay loam. In severely eroded areas, however, some of the lighter colored subsoil has been mixed into the surface layer. The subsoil ranges from light to heavy clay loam.

These soils are well aerated and have moderately slow permeability. The organic-matter content is low to medium. Unless limed, these soils are medium acid in the surface layer. They are normally low in available nitrogen, very low to low in available phosphorus, and low to medium in available potassium. Runoff is rapid, the soils are subject to erosion, and gullies form easily in waterways that are not protected.

Because of slope and very rapid runoff, the soils in this unit are not suited to row crops. They are used for pasture, trees, or wildlife habitat. Most areas are in bluegrass pasture. Farm machinery can be used in many areas to prepare a seedbed for the seeding of more productive grasses and legumes. Mowing weeds and controlling grazing help to increase the production of existing bluegrass pastures.

CAPABILITY UNIT VIe-2

This unit consists of deep, strongly sloping and moderately steep, somewhat poorly drained soils on side slopes of uplands. These soils are in the Caleb, Gara, Lamoni, Lindley, Mystic, and Shelby series. The soils in this unit have a surface layer of loam or clay loam. The subsoil is finer textured and ranges from heavy clay loam to heavy loam.

These soils have high to moderate available water capacity and moderate to slow permeability. Root development is restricted in some of the soils by the clayey, impermeable subsoil. The organic-matter content is low. Unless limed, these soils are medium acid in the surface layer. They are low to very low in available nitrogen and phosphorus and are low to medium in available potassium.

The soils in this unit are not suited to row crops. Most areas are in pasture or woodland pasture, but some small areas are managed as cropland with more suitable soils. These soils are subject to severe erosion hazard. In some small areas wetness and seepage from more permeable, adjacent soils upslope limit the choice of plants and management.

Mowing weeds, controlling grazing, and seeding to more productive grasses and legumes increase the carrying capacity of pastures. Interceptor tile placed in adjacent soils upslope reduces wetness of some areas and assists in establishing deep-rooted legumes. Many areas presently in woodland pasture would be more productive if livestock were fenced out and good woodland management practiced.

Most areas of these soils are suited to the construction of farm ponds, and many sites are available for constructing them.

CAPABILITY UNIT VIe-3

This unit consists mainly of strongly sloping, moderately well drained to somewhat poorly drained soils that formed mainly in material weathered from shale on uplands. These soils are in the Clanton, Gosport, and Mystic series. Their surface layer in most areas is silt loam, and their subsoil is mainly silty clay loam or silty clay. In some areas part of the subsoil and the surface layer are mixed with glacial material and contain more fine sand, some gravel, and small pebbles. Areas of Mystic soils are loamy in the surface layer and have a clay loam subsoil. Mystic soils formed in reworked glacial till material.

Soils in this unit have medium to low available water capacity, except for the Mystic soils, which have high available water capacity. Runoff is very rapid after the surface layer is saturated. The root zone is unfavorable because of the shale and the very slow permeability of the Clanton soils. The organic-matter content and natural fertility of these soils are low. Unless limed, these soils are slightly acid to medium acid in the surface layer. They are low to very low in available nitrogen, phosphorus, and potassium.

Most areas are in permanent pasture or timbered pasture. A few are practical to manage as cropland with more suitable, moderately sloping and strongly sloping soils.

The soils in this unit are not suited to crops, and they have some limitations for pasture. Erosion, gullying, low fertility, and poor response to treatment are the most limiting factors. The Clanton and Gosport soils also are droughty.

Control of grazing, seeding more productive pasture plants where practical, and mowing weeds increase the productivity of existing pastures. Many areas presently in timbered pasture would be more productive if managed as woodland and fenced from livestock.

CAPABILITY UNIT VIIe-1

This unit consists of deep, moderately well drained to somewhat poorly drained, moderately steep, severely eroded soils and steep to very steep, slightly eroded to moderately eroded soils on uplands. These soils are in the Gara and Lindley series and the Shelby-Lamoni complex. Their surface layer is loam in most areas. Where erosion has been severe, the surface layer is clay loam or loam and is hard when dry. The subsoil is finer textured and is mainly firm clay loam.

These soils have very rapid runoff and are easily gullied because of the steep slopes. They have high available water capacity and moderately slow to slow permeability. Their properties are favorable for deep root development. The organic-matter content of the surface layer ranges from very low to medium. Unless limed, these soils are typically medium acid or strongly acid in the surface layer. They are mostly very low to low in available nitrogen and phosphorus and low to medium in available potassium.

Areas of these soils are large and are mainly in pasture, timbered pasture, or woodland. The soils are not suited to crops and have severe limitations for pasture because of steep and very steep slopes. In areas not too steep for the use of farm machinery, mowing and seeding more productive grasses and legumes increase the carrying capacity of pasture. The soils are suited to woodland and wildlife habitat.

Selective cutting and removal of undesirable trees and brush improve the yield of woodland products. Many wooded areas, presently being pastured, would be more productive if livestock were fenced out and good woodland management practiced.

These soils are suited to pond construction for gully control, water supplies, wildlife habitat, and recreation areas.

CAPABILITY UNIT VIIe-2

This unit consists of moderately steep to very steep soils in the Clanton, Gosport, and Mystic series. Except for the Mystic soils, the soils in this unit formed in material weathered from shale on uplands. The Mystic soils formed in reworked glacial till. The surface layer of the soils in this unit is silt loam or light loam, and the subsoil is firm or very firm silty clay loam or silty clay. The subsoil of the Mystic soils is clay loam. In some places, especially in the Gosport soils, the subsoil and surface layer is mixed with glacial material and contains sand- and gravel-size particles.

These soils have medium to low available water capacity, except for the Mystic soils, which have high available water capacity. Permeability is mainly very slow, and runoff is rapid or very rapid. The organic-matter content is low to very low. Unless limed, these soils are medium acid to slightly acid in the surface layer. They are normally very low in available nitrogen and phosphorus and are very low to low in available potassium.

Most areas of these soils are in pasture, timbered pasture, or woodland and are inaccessible to farm machinery. The soils are suited to pasture, woodland, or wildlife habitat. The hazard of severe erosion, low fertility, poor response to treatment, and droughtiness limit their use and productiveness. Control of grazing in pasture areas and renovation and seeding of more productive pasture plants where practical, increase the carrying capacity. Tree growth is slow. Selective cutting and other woodland management practices increase yields and improve the stand of desirable trees. Many wooded areas, presently being pastured, would be more productive if livestock were fenced out and good woodland management practiced.

CAPABILITY UNIT VIIe-3

This unit consists of strongly sloping to very steep soils on side slopes of uplands in rocky areas. It is made up of Sloping stony land, Steep rock land, and soils in the Gosport, Hixton, and Nordness series.

The soils and land types in this capability unit have a wide range in color, texture, and depth to limestone, sandstone, or shale. Their surface layer ranges from clay loam or silt loam in Sloping stony land to fine sandy loam in the Hixton soils. Rock and limestone fragments are common on the surface, except in sandy areas. Rock outcrops and ledges are common on very steep and extremely steep side slopes. The subsoil is thin, and the available water capacity is low.

These soils are subject to severe erosion, and their use is limited by droughtiness and low natural fertility. The root zone is shallow in most places. Runoff is very rapid, and most areas are dissected by rocky ravines and gullies.

Soils in this unit are used for woodland and wildlife habitat. Some areas will support pasture grasses. Farm machinery cannot be used in most areas. Clearing of brush and trees in moderately steep and strongly sloping areas improves the stand and quality of grasses. Most areas are large and in woodland or woodland pasture.

Selective cutting and thinning improves woodland, but most areas are left in their native state. An undesirable wildlife inhabitant in the rocky areas is the timber rattlesnake.

Predicted Yields

In table 2 the average acre yields of principal crops are predicted for a high level of management.

Under this level of management, erosion is controlled; organic-matter content and soil tilth are maintained; the level of fertility for each crop is maintained, as indicated by soil tests and field trials; the water level in wet soils is controlled; weed and pest control are excellent; and operations are timely. A relatively small percentage of farmers now provide this level of management.

All available sources of yield information were used in making these predictions. The sources include data from the federal census, Iowa farm census, experimental farms, and cooperative experiments with farmers, as well as on-farm experience by soil scientists, extension workers, and others.

The yield predictions are designed to serve as guides. They are approximate values only and should be so considered. Of more value than actual yield figures to many users will be the comparative yields between soils. These relationships are likely to remain fairly consistent over a period of years. On the other hand, actual yields have been increasing in past years. If they continue to increase as expected, predicted yields in this table will soon be too low.

Woodland, Wildlife, and Recreation [2]

Approximately 42,000 acres, or about 12 percent of the county, is wooded. At the time of settlement about 70,000 acres were in timber (*4*). This was confined mainly to the Clinton-Lindley-Steep rock land-Clanton association, but timber also covered the more hilly parts of other associations.

Native timber is still being cleared, but not extensively. Large wooded areas are now confined mainly to steep slopes near major streams.

Woodland, wildlife, and recreation are so closely related that some reference to each is made in discussing the suitability of soils in Madison County for these purposes. This section is of special interest to anyone who enjoys the outdoors and is concerned with the preservation of areas not suited to crops or pasture, but suited to woodland or wildlife habitat or suitable for recreation.

Woodland

Most of the natural forest growth is on the steep slopes and rock land adjacent to North River, Middle River, and Clanton and Jones Creeks, and their smaller tributaries. Smaller areas are near Grand River in the southwestern part of the county and South River in the southeastern part.

A few farms have small woodlots. Planting of trees and shrubs is common around farms for windbreaks or landscaping. As the size of individual farm units increases, many abandoned farmsteads are being converted to crops or pasture.

Most of the existing woodland areas in the county are subject to grazing and are used for timber pasture. Few areas are managed only as woodland. Very steep areas are left untouched and produce little feed. Where these areas adjoin pasture areas, they provide little more than shade for livestock and habitat for wildlife.

The acreage of these wooded areas has not changed significantly in recent years, but some clearing and conversion to crops or pasture is carried on each year. Other than the clearing of small woodlots adjacent to abandoned farmsteads, the more recent conversions are on ridgetops, short, moderately sloping side slopes, and river bottoms.

The timbered soils on uplands, notably Clinton, Gara, Givin, and Ladoga soils, and the Kennebec, Nodaway, and Spillville soils on bottom lands are the ones most commonly cleared. These soils have a higher capability for crops or pasture.

Early clearing in the county included strongly sloping and moderately steep slopes of the Gara and Lindley soils. These soils have a lower capability for crops, and some have been very severely eroded. These areas are of low value. Replanting to suitable species of trees is one alternative for longtime, more profitable land use.

Proper management of areas suitable only as woodland can increase the value of the land and increase the chance for profitable use. Several agencies in Iowa have programs to assist woodland owners in improving the quality of woodland products and to inform them about basic marketing practices.

Soil Conservation Service technicians assist in determining the best land use. Local district foresters employed by the State Conservation Commission assist in development of woodland management plans for both new and old timber stands.

Woodland products of Madison County that could be developed on a more profitable basis are mainly veneer, rough timber for temporary construction, pallets, and tight cooperage. New plantings of rapidly growing pines could, at the present time, be used primarily for Christmas trees and beautification of recreation areas.

Woodland suitability groups

The soils of Madison County have been placed in 11 woodland suitability groups to assist owners of woodland in planning the use of their soils. Each group is made up of soils that have about the same available water capacity and other characteristics that influence the growth of trees. These soils also have similar limitations and are subject to the same hazards when used for trees. All the soils in one group, therefore, support similar kinds of trees, have about the same potential productivity, and require similar kinds of management.

The brief description of each woodland group gives the main characteristics of the soils and the existing limitations and hazards that affect woodland production. Some suitable species for the group are also listed. This listing includes species suitable for veneer, lumber, windbreaks, and Christmas trees, as well as shrubs and trees suitable for wildlife habitat. The elm is one of the most numerous

[2] DUANE STOPPEL, district forester, Adel, Iowa, assisted in preparing this subsection.

TABLE 2.—*Predicted average acre yields of principal crops under a high level of management*

[Dashes indicate that the soil is not suited to the crop or that the crop ordinarily is not grown]

Soil	Corn	Soybeans	Oats	Alfalfa-grass	Pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days*[1]
Alluvial land	----	----	----	----	[2]
Alluvial land, channeled	----	----	----	----	[2]
Arbor loam, 9 to 14 percent slopes	85	33	59	3.4	170
Bremer silty clay loam	105	45	75	4.5	225
Caleb loam, 9 to 14 percent slopes, moderately eroded	65	24	45	1.6	80
Caleb-Mystic loams, 9 to 14 percent slopes, moderately eroded	60	23	42	1.5	75
Caleb-Mystic loams, 14 to 18 percent slopes, moderately eroded	55	----	38	1.3	65
Clanton silt loam, 9 to 14 percent slopes, moderately eroded	----	----	----	----	35
Clanton silt loam, 14 to 25 percent slopes, moderately eroded	----	----	----	----	30
Clanton-Gosport silt loams, 9 to 14 percent slopes, moderately eroded	----	----	----	----	35
Clanton-Gosport silt loams, 14 to 18 percent slopes, moderately eroded	----	----	----	----	30
Clanton-Gosport silt loams, 18 to 25 percent slopes, moderately eroded	----	----	----	----	30
Clanton-Gosport silt loams, 25 to 40 percent slopes, moderately eroded	----	----	----	----	20
Clarinda silty clay loam, 5 to 9 percent slopes	65	24	45	1.8	90
Clarinda silty clay loam, 5 to 9 percent slopes, moderately eroded	55	21	38	1.5	75
Clearfield silty clay loam, 5 to 9 percent slopes	83	27	61	3.0	150
Clearfield silty clay loam, 5 to 9 percent slopes, moderately eroded	78	25	58	2.8	140
Clinton silt loam, 2 to 5 percent slopes	94	36	71	4.2	210
Clinton silt loam, 5 to 9 percent slopes	92	32	69	4.0	200
Clinton silt loam, 5 to 9 percent slopes, moderately eroded	90	31	67	4.0	200
Clinton silt loam, 9 to 14 percent slopes, moderately eroded	86	26	59	3.8	190
Clinton silt loam, benches, 2 to 5 percent slopes	96	34	71	4.2	210
Colo silty clay loam	105	44	75	4.2	210
Colo silty clay loam, channeled	----	----	----	----	100
Colo-Ely silty clay loams, 2 to 5 percent slopes	95	36	70	3.6	190
Colo-Ely silty clay loams, gullied, 2 to 5 percent slopes	----	----	----	----	120
Dunbarton silt loam, deep variant, 9 to 14 percent slopes, moderately eroded	----	----	----	1.0	50
Ely silty clay loam, 2 to 5 percent slopes	110	44	78	4.4	220
Flaggy alluvial land	----	----	----	----	40
Gara loam, 5 to 9 percent slopes, moderately eroded	80	30	60	2.8	140
Gara loam, 9 to 14 percent slopes, moderately eroded	75	28	57	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
Gara loam, 18 to 25 percent slopes, moderately eroded	----	----	----	1.6	90
Gara loam, 25 to 40 percent slopes	----	----	----	----	50
Givin silt loam	100	41	74	4.2	220
Givin silt loam, benches	100	43	74	4.2	220
Gosport silt loam, 14 to 18 percent slopes	----	----	----	----	25
Gosport silt loam, 18 to 25 percent slopes	----	----	----	----	25
Hixton fine sandy loam, 20 to 40 percent slopes	----	----	----	----	25
Judson silty clay loam, 2 to 6 percent slopes	110	44	78	4.8	240
Kennebec silt loam	115	44	78	4.8	240
Keswick loam, 9 to 14 percent slopes, moderately eroded	55	20	38	1.4	70
Ladoga silt loam, 2 to 5 percent slopes	97	38	72	4.5	225
Ladoga silt loam, 2 to 5 percent slopes, moderately eroded	95	36	71	4.2	210
Ladoga silt loam, 5 to 9 percent slopes	95	32	71	4.2	210
Ladoga silt loam, 5 to 9 percent slopes, moderately eroded	93	32	70	4.0	200
Ladoga silt loam, 9 to 14 percent slopes	93	31	65	3.4	170
Ladoga silt loam, 9 to 14 percent slopes, moderately eroded	92	30	63	3.4	170
Ladoga silt loam, 14 to 18 percent slopes, moderately eroded	75	----	52	3.0	150
Ladoga silt loam, benches, 2 to 5 percent slopes	97	38	72	4.2	210
Lamoni clay loam, 5 to 9 percent slopes	67	25	51	2.5	125
Lamoni clay loam, 5 to 9 percent slopes, moderately eroded	65	23	50	1.8	90
Lamoni clay loam, 9 to 14 percent slopes	57	22	40	1.6	80
Lamoni clay loam, 9 to 14 percent slopes, moderately eroded	55	20	38	1.4	70
Lamoni clay loam, 9 to 14 percent slopes, severely eroded	----	----	----	1.2	60
Lindley loam, 9 to 14 percent slopes, moderately eroded	68	23	47	2.3	115
Lindley loam, 14 to 18 percent slopes, moderately eroded	----	----	----	1.8	90
Lindley loam, 18 to 25 percent slopes	----	----	----	1.6	80
Lindley loam, 25 to 40 percent slopes	----	----	----	----	40
Lindley soils, 14 to 18 percent slopes, severely eroded	----	----	----	1.6	80
Macksburg silty clay loam, 0 to 2 percent slopes	120	45	81	4.8	240
Macksburg silty clay loam, 2 to 5 percent slopes	110	42	75	4.6	230
Martinsburg silt loam, 2 to 5 percent slopes	100	40	75	4.0	200
Mystic loam, 9 to 14 percent slopes, moderately eroded	60	21	42	1.4	70

See footnotes at end of table.

TABLE 2.—*Predicted average acre yields of principal crops under a high level of management*—Continued

Soil	Corn	Soybeans	Oats	Alfalfa-grass	Pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [1]
Mystic-Clanton complex, 9 to 14 percent slopes, moderately eroded	----	----	----	1.2	60
Mystic-Clanton complex, 14 to 18 percent slopes, moderately eroded	----	----	----	0.8	50
Nevin silty clay loam, 0 to 2 percent slopes	120	45	85	4.8	240
Nevin silty clay loam, 2 to 5 percent slopes	110	42	78	4.6	230
Nira silty clay loam, 5 to 9 percent slopes, moderately eroded	90	33	67	4.0	200
Nodaway silt loam	110	44	78	4.0	150
Nodaway silt loam, channeled	----	----	----	3.0	150
Nodaway-Martinsburg silt loams, 2 to 5 percent slopes	100	37	75	4.0	200
Nordness loam, 15 to 25 percent slopes	----	----	----	----	40
Olmitz loam, 2 to 5 percent slopes	96	40	72	4.4	220
Olmitz loam, 5 to 9 percent slopes	88	37	66	3.8	190
Sharpsburg silty clay loam, 0 to 2 percent slopes	115	44	78	4.8	240
Sharpsburg silty clay loam, 2 to 5 percent slopes	108	42	72	4.6	230
Sharpsburg silty clay loam, 2 to 5 percent slopes, moderately eroded	95	36	71	4.4	220
Sharpsburg silty clay loam, 5 to 9 percent slopes	95	36	71	4.4	220
Sharpsburg silty clay loam, 5 to 9 percent slopes, moderately eroded	93	33	70	4.2	210
Sharpsburg silty clay loam, 9 to 14 percent slopes, moderately eroded	90	30	63	3.6	180
Sharpsburg silty clay loam, benches, 0 to 2 percent slopes	110	45	78	4.8	240
Sharpsburg silty clay loam, benches, 2 to 5 percent slopes	102	42	72	4.6	230
Shelby loam, 9 to 14 percent slopes, moderately eroded	75	29	52	2.5	125
Shelby loam, 14 to 18 percent slopes	67	----	50	2.4	120
Shelby loam, 14 to 18 percent slopes, moderately eroded	60	----	45	2.2	110
Shelby loam, 18 to 25 percent slopes, moderately eroded	----	----	----	1.5	75
Shelby soils, 14 to 18 percent slopes, severely eroded	----	----	----	2.0	100
Shelby-Lamoni complex, 5 to 9 percent slopes, moderately eroded	75	25	52	2.5	125
Shelby-Lamoni complex, 9 to 14 percent slopes	70	23	49	2.3	115
Shelby-Lamoni complex, 9 to 14 percent slopes, moderately eroded	63	23	46	2.3	100
Shelby-Lamoni complex, 9 to 14 percent slopes, severely eroded	----	----	42	1.5	75
Shelby-Lamoni complex, 14 to 18 percent slopes, moderately eroded	----	----	----	1.2	60
Shelby-Lamoni complex, 14 to 18 percent slopes, severely eroded	----	----	----	1.0	50
Sloping stony land	----	----	----	----	40
Sperry silt loam	85	38	63	3.8	190
Spillville loam	115	44	81	4.8	240
Spillville loam, flaggy substratum	100	40	75	4.5	200
Steep rock land	----	----	----	----	10
Vesser silt loam, 0 to 2 percent slopes	95	40	68	4.0	200
Vesser silt loam, 2 to 5 percent slopes	90	37	64	3.5	175
Wabash silty clay	70	30	49	3.0	150
Wabash silty clay loam	75	32	52	3.5	175
Winterset silty clay loam	107	42	76	4.4	220
Wiota silt loam, 0 to 2 percent slopes	117	44	82	4.8	240
Wiota silt loam, 2 to 5 percent slopes	112	42	81	4.6	230
Zook silty clay loam, 0 to 2 percent slopes	85	37	65	3.8	190
Zook silty clay loam, 2 to 5 percent slopes	85	35	60	3.5	175

[1] A term 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. In estimating the animal-unit-days listed in this table, it was assumed that one mature animal consumes 40 pounds of dry forage per day. Predicted yields are based on alfalfa-grass except for those soils where no hay yields are given. For those soils the yields are based on permanent bluegrass pasture.

[2] Variable, depending on frequency of stream overflow.

and most common species of hardwood trees in the county. Nevertheless, it is not listed as a recommended species, because of the Dutch elm disease, which is rapidly killing existing stands. Many thousands of elms still remain, but dead and dying trees present a management problem because they need to be removed. Of those species listed as suitable for windbreaks, the conifers listed are especially suited to farmstead windbreaks, and the hardwoods listed are especially suited to field windbreaks.

For most of the groups, the site index ratings are given for suitable trees. The site index is the total height, in feet, of the dominant and codominant trees in the stand at 50 years of age. It is a rating of potential productivity.

The names of soil series represented are mentioned in the description of each woodland group, but this does not mean that all the soils of a given series are in that group. To find the names of all the soils in any woodland group, refer to the "Guide to Mapping Units" at the back of this survey.

WOODLAND SUITABILITY GROUP 1

This group consists of soils of the uplands that are shallow to bedrock. Nordness soils, Sloping stony land,

and Steep rock land are in this group. The slopes range from 9 to 25 percent, except for Steep rock land, which has slopes of 25 to 70 percent or more. Rainwater runs off rapidly, and the available moisture capacity is low to very low.

The suitability of these soils for upland hardwoods is poor. The measured average site index for upland hardwoods is less than 45. Estimated production of timber from existing stands is less than 100 board feet per acre per year (*23*). Most areas of soils in this group have existing stands, but many of these are thin and of poor quality. Trees that should be favored in existing stands are green ash, hackberry, red oak, and white oak.

The seedling mortality is slight to severe on these soils, depending on the amount of competition from grass. Erosion is a moderate to very severe hazard, depending on slope. Pest and disease hazards are slight. The equipment limitation is slight on slopes up to 18 percent and moderate to severe on steeper slopes.

Trees most suitable for open-land noncommercial planting or for wildlife habitat and beautification are eastern white pine, Scotch pine, red pine, European larch, and eastern redcedar. In addition, red oak, white oak, and basswood are suited to noncommercial interplanting. Trees most suitable for windbreaks are eastern white pine, Scotch pine, red pine, and eastern redcedar. Species particularly suitable for wildlife plantings are honeysuckle and ninebark.

WOODLAND SUITABILITY GROUP 2

The group is made up of Alluvial land; Alluvial land, channeled; Flaggy alluvial land; and soils of the Dunbarton series, deep variant, and the Colo, Ely, Hixton, and Spillville series. Most of these soils have limestone bedrock, sandstone, or fragmented limestone at depths generally between 20 and 36 inches. Alluvial land consists of sandy to clayey soil material several feet thick. The Hixton soils and the Dunbarton soils, deep variant, are on uplands and have slopes ranging from 9 to 40 percent. The other soils lie along streams and are nearly level.

The available water capacity of these soils is low to medium. The principal factors that limit tree growth on the uplands are inadequate moisture supply and the erosion hazard. Shallow root penetration and frequent flooding limit woodland growth on Flaggy alluvial land and the Spillville soil. Alluvial land and Alluvial land, channeled, are variable in available water capacity, but they permit good root penetration.

The suitability of these soils for hardwoods is fair to good. The suitability of the soils on uplands for conifers is good. The average site index for upland hardwoods ranges from 46 to 65. Estimated production of timber from existing stands ranges from 100 to 200 board feet per acre per year. Most areas of soils in this group have existing stands, but many of these are thin and of poor quality. Trees that should be favored in existing stands are red oak, white oak, green ash, hackberry, and cottonwood.

The seedling mortality is generally slight, but it depends on the amount of detrimental deposition in the bottom lands. Plant competition from grass, weeds, or undesirable trees is slight to moderate, depending on the amount of competition from grass. Erosion is a slight hazard on bottom lands and a severe hazard on the uplands. The equipment limitation is slight on slopes up to 18 percent and moderate to severe on steeper slopes.

The conifers most suitable for open-land planting or for interplanting in existing stands are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir. The most suitable hardwoods are walnut, green ash, and hackberry. In addition, red oak, white oak, and basswood are suitable for interplanting. Trees most suitable for windbreaks are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir. Honeysuckle is a suitable shrub. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 3

This group consists of well drained and moderately well drained, medium-textured and moderately fine textured soils on uplands and benches. The slopes range from 0 to 18 percent. Soils on uplands in the group are in the Clinton, Ladoga, Nira, and Sharpsburg series. Judson, Martinsburg, and Wiota soils are on foot slopes and benches. All of the soils in this group formed in loess except the Judson and Martinsburg soils, which formed in local silty alluvium. They have moderate to moderately slow permeability, and the available water capacity is high.

The suitability of these soils for upland hardwoods, conifers, and cottonwoods is excellent. The measured average site index for upland hardwoods ranges from 76 to 85. Estimated production of timber from existing stands ranges from 250 to 300 or more board feet per acre per year in well-managed and fully stocked stands. Trees that should be favored in existing hardwood stands are walnut, white oak, red oak, green ash, hard maple, basswood, and wild black cherry.

The seedling mortality on these soils is slight. Plant competition from grass or weeds or undesirable species of trees is slight to severe, depending on competition from grasses, such as bromegrass. The principal limitation for tree growth is plant competition. The erosion hazard is slight on the nearly level or gently sloping soils but is moderate on the steeper soils. Equipment limitations are slight.

The conifers most suitable for open-land noncommercial planting or for wildlife habitat and beautification are eastern white pine, red pine, Norway spruce, Scotch pine, European larch, and eastern redcedar. The most suitable hardwoods are walnut, green ash, hackberry, and hard maple. In addition, red oak, white oak, and basswood are suitable for noncommercial interplanting. The trees most suitable for windbreaks are eastern white pine, red pine, Norway spruce, white spruce, eastern redcedar, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. The conifers listed are especially suited to farmstead windbreaks, and the hardwoods are especially suited to field windbreaks. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 4

This group consists of moderately fine textured soils that are chiefly well drained and moderately well drained. These soils are in the Arbor, Gara, Lindley, Lamoni, Olmitz, and Shelby series. All the soils formed in glacial till, except the Olmitz soils, which formed in local alluvium. Slopes are 2 to 18 percent. These soils have moderate to moderately slow permeability and high available water capacity. The Lamoni soils in the Shelby-Lamoni complexes are somewhat poorly drained.

The suitability of these soils for hardwoods is good to very good. The suitability for conifers is good and for cottonwood is very good. The average site index for upland hardwoods ranges from 56 to 75. Estimated production of timber from existing stands ranges from 150 to 250 board feet per acre per year. Trees that should be favored in existing stands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

The seedling mortality is slight to moderate on these soils. Plant competition from grass, weeds, or undesirable trees is slight to moderate, depending on the amount of competition from grasses, such as bromegrass. Erosion is a slight to moderate hazard, depending on the slope. Olmitz soils are subject to rilling and gullying rather than significant sheet erosion. The equipment limitation is slight.

The conifers most suitable for open-land noncommercial planting or for wildlife habitat and beautification are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, and Douglas-fir. The most suitable hardwoods are black walnut, green ash, and hackberry. In addition, red oak, white oak, and basswood are suitable for noncommercial interplanting. The conifers most suitable for windbreaks are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir. The most suitable hardwoods are Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. The conifers listed are especially suited to farmstead windbreaks, and the hardwoods are especially suited to field windbreaks. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 5

This group consists of well drained and moderately well drained soils that have a moderately fine textured subsoil. These soils are in the Gara, Lindley, and Shelby series. They have north- and northeast-facing slopes of 18 to 40 percent and are on uplands. The soils formed in glacial till. They have moderately slow permeability and high available water capacity. The principal factor that limits tree growth is lack of adequate moisture because of climate and runoff.

The suitability of these soils for hardwoods is fair, but suitability is good for conifers and cottonwood. The average site index for upland hardwoods ranges from 46 to 55. Estimated production of timber from existing stands ranges from 100 to 150 board feet per acre per year in well-managed, fully stocked stands. Trees that should be favored in existing hardwood stands are green ash, hackberry, cottonwood, red oak, and white oak. Walnut should also be favored on such sites as those in protected coves.

The seedling mortality is slight on these soils. Plant competition from grass, weeds, or undesirable species of trees is slight to severe. The equipment limitation is moderate, and erosion is a moderate hazard.

Trees most suitable for open-land noncommercial planting or for wildlife habitat and beautification are Scotch pine, European larch, and eastern redcedar. Trees suitable for noncommercial interplanting in existing stands, in addition to those just listed, are basswood, red oak, and white oak. The conifers most suitable for windbreaks are Scotch pine, eastern redcedar, Austrian pine, ponderosa pine, and Douglas-fir. The most suitable hardwoods for windbreaks are Norway poplar, Siouxland poplar, Robusta poplar, green ash, Russian-olive, and hackberry. Species suitable for wildlife plantings are ninebark, honeysuckle, dogwood, and wild plum.

WOODLAND SUITABILITY GROUP 6

This group consists of well drained and moderately well drained soils that have a moderately fine textured subsoil. These soils are in the Gara, Lindley, and Shelby series. They have south- and southwest-facing slopes of 18 to 40 percent and are on uplands. The soils formed in glacial till. These soils have moderately slow permeability and high available water capacity. The principal factor that limits tree growth is lack of adequate moisture because of climate and runoff.

The suitability of these soils for hardwoods is poor. Suitability is fair for conifers and good for cottonwood. The average site index for upland hardwoods is less than 45. Estimated production of timber from existing stands is less than 100 board feet per acre per year. Trees that should be favored in existing stands are green ash, hackberry, cottonwood, red oak, and white oak. Walnut should also be favored in coves.

The seedling mortality is slight on these soils. Plant competition from grasses, weeds, or undesirable species of trees is severe. The equipment limitation is moderate. The climatic and erosion hazards are severe.

The species most suitable for open-land noncommercial planting or for wildlife habitat and beautification are Scotch pine, European larch, and eastern redcedar. Trees suitable for noncommercial interplanting in existing stands are the species just mentioned and basswood, red oak, and white oak. The trees most suitable for windbreaks are eastern redcedar, ponderosa pine, Austrian pine, and Douglas fir. Wild plum is suitable for wildlife plantings.

WOODLAND SUITABILITY GROUP 7

This group consists of moderately well drained and somewhat poorly drained soils that have a moderately fine textured or fine textured subsoil. They have slopes of 9 to 18 percent and are on uplands. These soils are in the Caleb, Clanton, Keswick, and Mystic series. Available water capacity is medium to high except in the Clanton soils, which have low available water capacity. Permeability ranges from moderate to moderately slow in the Caleb soils to very slow in the Clanton soils. The principal limitation that affect tree growth on these soils are the texture and permeability of the soils.

The suitability of these soils is poor for hardwoods, poor for conifers, and fair for cottonwood. Trees are recommended for planting primarily for cover and beautification. The average site index for hardwoods is less than 45. Estimated production of timber from existing stands is less than 100 board feet per acre per year. Trees that should be favored in existing stands are eastern white pine, Scotch pine, eastern redcedar, Norway spruce, green ash, hackberry, red oak, white oak, and cottonwood.

Seedling mortality is slight. Plant competition from undesirable species is slight. The equipment limitation is moderate. Erosion is a severe hazard.

The conifers most suitable for open-land noncommercial planting or for wildlife habitat and beautification are eastern white pine, Scotch pine, eastern redcedar, and Norway spruce. The most suitable hardwoods for open-land noncommercial planting are green ash, hackberry, red oak, and white oak. In addition, basswood is suitable for interplanting. The conifers most suitable for windbreaks are eastern white pine, Scotch pine, eastern redcedar, and Norway spruce. The most suitable hardwoods for windbreaks are Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. Windbreak site quality is poor. Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, and dogwood.

WOODLAND SUITABILITY GROUP 8

This group consists of somewhat poorly drained, nearly level to gently sloping soils on uplands and on second bottoms. These soils are in the Ely, Givin, Nevin, and Macksburg series. Runoff is slow. They have moderately slow or moderate permeability, and available water capacity is high. The principal limitation that affects tree growth is wetness.

The suitability of these soils for hardwoods and conifers is good. Suitability for cottonwood is very good. The average site index for the hardwoods ranges from 56 to 65. Estimated production of timber from existing stands ranges from 150 to 200 board feet per acre per year (*23*). Trees that should be favored in existing stands are green ash, hackberry, white oak, red oak, and cottonwood. However, there are few existing stands because most areas are cultivated.

The seedling mortality is slight. Plant competition from undesirable species is moderate. The equipment limitation is slight, and the erosion and disease hazards are slight.

Trees most suitable for open-land noncommercial planting or for wildlife habitat and beautification are eastern white pine, Scotch pine, red pine, Norway spruce, eastern redcedar, European larch, green ash, walnut, and hackberry. Trees suitable for interplanting are those just named and also basswood. The conifers most suitable for windbreaks and wildlife plantings are eastern white pine, Scotch pine, red pine, Norway spruce, and eastern red cedar. The most suitable hardwoods for windbreaks are Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. The shrubs most suitable are honeysuckle and red-osier dogwood.

WOODLAND SUITABILITY GROUP 9

This group consists of somewhat poorly drained and poorly drained soils that have a fine textured and moderately fine textured subsoil on uplands. These soils are in the Clanton, Clarinda, Gosport, and Lamoni series. Slopes are mainly 5 to 18 percent, but in some places they are as much as 40 percent. Permeability of these soils is slow or very slow, and the available water capacity ranges from low in the clayey Clanton soils to high in the Lamoni soils. Runoff is generally rapid. The principal limitations for tree growth are seasonal wetness and seepiness and the slow to very slow permeability of these soils.

The suitability of these soils is poor for upland wood crops, poor for conifers, and poor for cottonwood. The average site index for upland hardwoods is less than 45. Estimated production of timber from existing stands is less than 100 board feet per acre per year. Trees that should be favored in existing hardwood stands are green ash, hackberry, and cottonwood. Seedling mortality is slight, and the erosion hazard is moderate.

Trees most suitable for open-land noncommercial planting or wildlife habitat and beautification are redcedar, Scotch pine, green ash, hackberry, and cottonwood. The conifers most suitable for windbreaks are redcedar and Scotch pine. The most suitable hardwoods are green ash, hackberry, and cottonwood. Windbreak site quality is good for green ash, hackberry, and cottonwood and poor for redcedar and Scotch pine.

WOODLAND SUITABILITY GROUP 10

This group consists of well-drained to somewhat poorly drained soils on bottom lands. These soils are nearly level and are medium textured to moderately fine textured. They are in the Kennebec, Martinsburg, Nodaway, and Spillville series. Runoff is slow. The soils have moderate permeability and high available water capacity.

The suitability of these soils for upland hardwoods is fair, for conifers is poor, and for bottom-land hardwoods is fair to good. Estimated production of timber from existing stands of cottonwood and bottom-land hardwoods ranges from 300 to 700 board feet per acre per year. Trees that should be favored in existing stands are cottonwood, soft maple, and green ash. These soils are not well suited to upland hardwoods or conifers.

Seedling mortality is slight to moderate. Plant competition from undesirable plants is moderate to severe, depending on the density of weeds. Giant ragweed and other weeds sometimes grow luxuriantly on these soils and make it difficult for new plantings to get started. The equipment limitation is slight, and erosion is a slight hazard.

Trees most suitable for windbreaks are cottonwood, soft maple, and green ash. Windbreak site quality is high for cottonwood and soft maple.

WOODLAND SUITABILITY GROUP 11

This group consists of poorly drained and very poorly drained soils on uplands and bottom lands. Clearfield, Sperry, and Winterset soils are on uplands. The Bremer, Colo, Ely, Vesser, Wabash, and Zook soils are on first and second bottoms. Most of the soils are nearly level, but some, such as the Clearfield and Vesser soils, are gently sloping and moderately sloping. Generally, the soils range from moderately slow to very slow in permeability, but the Ely and Vesser soils are moderately permeable. Available water capacity is high or medium.

The soils in this group are fertile, and most of them are not subject to erosion. The suitability of these soils for commercial wood crops is fair to poor because of wetness and poor drainage. Some areas on bottom lands are now in trees, and there are a few farm woodlots.

Trees suited to these soils are soft maple, cottonwood, sycamore, willow, green ash, and hackberry. Site suitability for these trees is good. Trees less suited to these soils are redcedar, eastern white pine, Scotch pine, Norway spruce, and European larch. These conifers are suited mainly to the better drained soils on uplands.

Wildlife

The soils of Madison County have a very wide range in topography, soil characteristics, and native vegetation, and they provide suitable habitats for a large number of wildlife species. Large acreages of nearly level to moderately sloping soils are farmed intensively, but they are so close to streams, steeper pasture, and wooded areas that all forms of wildlife in the county are well distributed throughout the county.

Much of the natural wildlife habitat is along the major streams and adjacent to the strongly sloping to steep Clanton, Gosport, Hixton, Gara, Lindley, and Nordness soils and Steep rock land. The more nearly level areas that are intensively farmed provide only limited shelter and nesting areas for birds and other wildlife, but corn and small grain are a source of feed.

Pheasants, which were introduced in the county some years ago, are becoming more numerous. There are still many quail in the county, but the distribution is not so general as in the past. Roadside clearing, spraying of weeds, and more intensive farming have reduced the cover required for quail. These birds now inhabit the rougher areas where woody growth is largely unattended. Waterfowl, such as ducks and geese, frequent the bayous and ponded areas in migration. Other waterfowl inhabit the more marshy areas.

The white-tailed deer are increasing in number. They are most common in soil associations 2 and 4, but they range over the whole county. They are often observed grazing with cattle.

Other kinds of wildlife are common in the county. Squirrel, woodchuck (groundhog), and cottontail rabbit are abundant in the uplands. There are some foxes and coyotes. Muskrats, mink, and some beavers frequent the streams, but beavers are not numerous. Skunk, opossum, and raccoon are common in the uplands.

Fish, mainly channel catfish, bullheads, and carp, are fairly numerous in the major streams. There are many privately owned, artificial ponds, ½ acre to 15 acres in size, that are well distributed in the county. Some ponds are well managed and provide excellent fishing of bass, bluegill, and catfish.

The wildlife resources of the county are important primarily for the opportunities they provide for recreation. Many kinds of wildlife, however, such as songbirds, hawks, owls, snakes, and other predators, also are beneficial in the control of rodents and insects.

Along with many harmless snakes, the county has one poisonous species, the timber rattlesnake. It inhabits the limestone ledges and limestone areas along North River, Middle River, Jones Creek, and Rattlesnake Run. It does not roam far from its den in the rocks, and the southern one-third of the county and the prairie soils are free of this undesirable snake. Its bite can be fatal if unattended, but if treated promptly by a physician there is little ill effect. Nature studies or hikes in these areas should be in pairs or groups, not by single individuals. Snakebite is very rare, but precautions must be taken if time is spent in these limestone areas.

Topography affects wildlife through its influence on land use. Some very steep and rough, rocky areas are of little value for crops or livestock, but an undisturbed plant cover is valuable to wildlife. If suitable vegetation is lacking in these areas, they can be improved and developed for desirable kinds of wildlife.

Internal drainage, available water capacity, texture of the subsoil, and permeability are some important factors in selecting sites for stocked farm ponds and in developing and maintaining habitats for waterfowl. Marshy areas can be improved for waterfowl and some fur-bearing animals.

Kinds of soil, slope, erosion, and the shape of the landscape govern the kind of vegetation that can be developed. Some small, odd-shaped, inaccessible areas of little value for other uses can be developed into useful wildlife areas.

Recreation

The properties of the soils, abrupt changes in topography, the rocky ledges, and vegetation in Madison County provide favorable conditions for recreational facilities. The close proximity of rough areas to fertile, intensively farmed areas adds to the scenic interest and the potential value for recreation.

Many recreational facilities have already been developed in the county. Increased travel by the public and the nearness of the county to the city of Des Moines, provide the opportunity and need for more recreational facilities. Pammel State Park, southwest of Winterset, has excellent camping, picnic, and hiking facilities. Of interest in that park are a tunnel cut through solid limestone and a ford across Middle River. The city park at Winterset also has excellent facilities including an observation tower, playgrounds and picnic areas, winding roads, and hiking trails. Seven covered bridges in the county are of interest to sightseeing motorists.

The city reservoir at Winterset and well-managed, privately owned ponds provide fishing and some boating. A privately owned recreational facility near the town of St. Charles has a pond for fishing and boating, dormitories and other facilities for summer camps, horseback riding, and hiking trails.

There are soils in all parts of the county that are good sites for the ponding of water (fig. 21). Among these soils are the Gara, Gosport, Lindley, and Shelby. The high potential for recreation is enhanced because suitable soils and areas are not confined to any one part of the county.

If planning, development, and management are good, almost any type of outdoor recreation can be provided. The soils of almost any capability unit or woodland suitability group will provide good wildlife habitat if properly used. The presence of wildlife will make other forms of outdoor recreation more enjoyable.

Figure 21.—This farm pond, in an area of Shelby soils, is used for recreation and provides water for livestock.

Engineering Uses of the Soils [3]

This section is useful to those who need to know the general suitability of soils when used as structural material or as foundations upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among the properties of soils most important in engineering are permeability, shear strength, compaction characteristics, soil drainage, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and topography. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, structures for storing and distributing water, and systems for disposal of sewage and waste materials.

This soil survey contains information that engineers can use to—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Choose potential sites for roads, highways, airports, pipelines, and underground cables.
3. Locate probable sources of sand, gravel, or road fill.
4. Plan and design farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate pavement and road rock performance with kinds of soils and develop information useful in development and maintenance of roads, culverts, and bridges.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement information already obtained from published maps, reports, and aerial photographs for purpose of making maps and reports.
8. Develop other preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 3, 4, and 5. These show, respectively, estimated engineering properties of the soils, behavior of the soils when used for specified engineering purposes, and results of tests on engineering soil samples.

This information, used with the soil map for identification, allows interpretations other than those given in

[3] DEANE S. GLEN, supervisory civil engineer, Soil Conservation Service, Des Moines, Iowa, assisted soil scientists in preparing this section.

tables 3, 4, and 5, but it does not eliminate need for sampling and testing at a site selected for an engineering work that involves heavy loads or that requires excavations to depths greater than those shown in the tables. Also, most areas of a soil mapping unit contain small areas of other kinds of soil that can have strongly contrasting properties and qualities and, therefore, different suitabilities or limitations for soil engineering. Engineers and others should not apply specific values to the estimates given for the bearing capacity of the soils.

Some terms used by soil scientists may be unfamiliar to engineers. These and other special terms used in a soil survey are defined in the Glossary at the back of this publication.

Engineering classification systems

The two systems most commonly used in classifying samples of soil horizons for engineering are the Unified system (*34*) used by Soil Conservation Service engineers, the U.S. Department of Defense, and others, and the AASHO (*1*) system adopted by the American Association of State Highway Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC, six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH, and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, ML-CL.

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A-7, are fine textured clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows, A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. If soil material is near a classification boundary it is given a symbol showing both classes, for example, A-2 or A-4. Within each group, the relative engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, is shown in table 5; the estimated classification for all soils mapped in the survey area is given in table 3.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary.

Estimated engineering properties

Estimated properties significant in soil engineering are given in table 3. These estimates are made for typical soil profiles, by layers sufficiently different to have different interpretations for soil engineering. The estimates are based on field observation made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soils in other counties. Following are explanations of some of the columns in table 3. Depth to bedrock was omitted because most of the soils in the county are deep enough over bedrock that bedrock does not generally affect their use. Clanton and Gosport soils are over shale bedrock, Dunbarton and Nordness soils are over limestone bedrock, and Hixton soils are over sandstone bedrock.

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

Soil texture is described in table 3 in the standard terms used by the U.S. Department of Agriculture. These terms take into account relative percentages of the size separates, sand, silt, and clay, in soil material that is less than 2.0 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. "Sand," "silt," "clay," and some of the other terms used in USDA textural classifications are defined in the Glossary of this soil survey.

Standard terms for texture frequently include reference to coarse fragments in the soil material, as for example, "gravelly loamy sand." Percentage of coarse fragments in a soil, also known as "coarse fraction," refers to stone fragments more than 2 millimeters in diameter.

Permeability relates to movement of water downward through undisturbed and uncompacted soil. It does not include lateral seepage, and it does not take into account such transient soil features as plowpans and surface crusts. Permeability is estimated on the basis of those soil characteristics that influence porosity, particularly structure and texture of the soil.

Available water capacity is the ability of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants. In table 3 it is expressed as inches of water per inch of soil.

Reaction is the degree of acidity or alkalinity of a soil expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material that has changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Engineering interpretations

The engineering interpretations in table 4 are based on the engineering properties of soils shown in table 3, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Madison County. Following are explanations of some of the columns in table 4.

Topsoil is used to cover or resurface an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are indications of suitability.

Road fill is soil material used in embankments for roads. As a low embankment or as the upper part of a high embankment, road fill serves as the subgrade or foundation for the road. For this reason, material good for road fill also needs to be good for subgrade.

The entire soil profile is evaluated to determine suitability for highway location. The ratings are for undisturbed soil without artificial drainage. Soil features considered are those that affect overall performance of the soil.

In determining the degree of limitation for foundations of low buildings, only undisturbed soils are considered. The buildings are less than three stories high and may be residential or light commercial buildings. The soil features affecting the degree of limitation are bearing strength, depth to the water table, texture, slope, erosion hazard, and flooding or ponding.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material of favorable stability, shrink-swell potential, shear strength, compactibility, and resistance to seepage. Presence of stones or organic material in a soil and susceptibility to piping are among factors that limit suitability.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture and structure, depth to claypan, rock, or other layers that influence rate of water movement, depth to the water table, slope, stability in ditchbanks, susceptibility to stream overflow, salinity or alkalinity, and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope, susceptibility to stream overflow, water erosion or soil blowing, content of stones or accumulations of salts and alkali, depth of root zone, rate of water intake at the surface, permeability below the surface layer and in the fragipan or other layers that restrict movement of water, amount of water held available to plants, and need for drainage or depth to water table.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope, depth to bedrock or other unfavorable material, presence of stones, permeability and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff, is not difficult to vegetate, and is not a potential source of silt that will fill channels.

The suitability of a soil for grassed waterways depends on soil features that affect establishment, growth, and maintenance of vegetation and layout and construction of the waterways.

Septic tank filter fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil properties considered are those that affect both adsorption of effluent and construction and operation of the system. Properties that effect adsorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Engineering test data

Table 5 contains engineering test data for some of the major soil series in Madison County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods, so the results are not satisfactory for assigning textural names used by the U. S. Department of Agriculture.

Moisture-density data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, optimum stability of earthwork is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. In table 5 liquid limit and plasticity index are based on tests of soil samples.

Soil features affecting highway work [4]

Many of the soils in Madison County have formed from loess that overlies glacial till. The loess ranges from more than 12 feet in thickness on nearly level uplands and ridgetops to thinner layers in more sloping, dissected areas. In many places where the landscape is dissected and sloping, glacial till is exposed and soils have formed in it. Soils in the county have also formed in material derived from sandstone, shale, or limestone, and in alluvium.

[4] By DONALD A. ANDERSON, soil engineer, Iowa State Highway Commission.

TABLE 3.—*Estimated properties*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping indicated. The symbol < means less

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture	Classification: Unified	Classification: AASHO
	Feet	*Inches*			
Alluvial land: Au. Soil properties are variable.	[1]				
Alluvial land, channeled: Av. Soil properties are variable.	[1]				
Arbor: AwD	3–5	0–14	Loam	CL	A–6(8–10)
		14–34	Clay loam	CL	A–6(8–12)
		34–50	Clay loam	CL	A–6(8–12)
Bremer: Br	1–3	0–19	Silty clay loam	MH or CH	A–7–5 or A–7–6 (12–16)
		19–42	Heavy silty clay loam	CH or CL	A–7–6 (16–18)
		42–50	Silty clay loam	CH or CL	A–7–6(13–17)
*Caleb: CbD2, CeD2, CeE2. For Mystic part of CeD2 and CeE2, see the Mystic series.	>5	0–15	Loam	CL	A–6(6–10)
		15–38	Sandy clay loam to clay loam.	CL to SC	A–4(4) to A–6(10)
		38–57	Sandy loam	SC or CL	A–4(1–4)
*Clanton: ClD2, ClF2, CmD2, CmE2, CmF2, CmG2. For Gosport part of CmD2, CmE2, CmF2, and CmG2, see Gosport series.	>5	0–11	Silt loam	ML–CL to CL	A–6
		11–38	Heavy silty clay loam to silty clay.	CH	A–7–6(16–20)
		38–48	Shaly silty clay loam	CH	A–7–6(16–20)
Clarinda: CnC, CnC2	[1]	0–16	Silty clay loam	CL or ML	A–6(6–10) to A–7–6(14)
		16–36	Silty clay	CH	A–7–6(20)
		36–52	Clay	CH	A–7–6(20)
Clearfield: CoC, CoC2	1–3	0–12	Silty clay loam	ML–CL	A–7–6(13–18)
		12–44	Silty clay loam	CH	A–7–6(15–20)
		44–52	Silty clay	CH	A–7–6(20)
Clinton: CsB, CsC, CsC2, CsD2, CtB	>5	0–9	Silt loam	ML or CL	A–6(10) to A–7–6(12)
		9–33	Silty clay loam or silty clay.	CH	A–7–6(15–18)
		33–52	Silty clay loam	CL	A–7–6(13)
*Colo: Cu, Cv, CwB, CyB. For Ely part of CwB and CyB, see Ely series.	[2] 1–3	0–18	Light silty clay loam	OH or CL	A–6(10)
		18–58	Silty clay loam	CL–CH	A–6(12) to A–7–6(14–18)
Dunbarton: DbD2	>5	0–15	Silt loam and silty clay loam.	ML or CL	A–6(6–10)
		15–30	Clay and silty clay	CH	A–7–6(15–20)
		30	Limestone bedrock.		
Ely: ElB	2–6	0–18	Light silty clay loam	CL	A–7–6(12–15)
		18–39	Silty clay loam	CL–CH	A–7–6(14–18)
		39–54	Light silty clay loam	CL–CH	A–7–6(14–18)
Flaggy alluvial land: Fg. Soil properties are variable.	>5				
Gara: GaC2, GaD2, GaE, GaE2, GaF2, GaG	>5	0–11	Loam	CL	A–4(3) to A–6(8)
		11–38	Heavy clay loam	CL or CH	A–7–6(14–17)
		38–50	Clay loam	CL or CH	A–6(10) to A–7–6(18)
Givin: Gn, Go	2–4	0–21	Silt loam and silty clay loam.	ML or CL	A–6(10) to A–7–6(13)
		21–34	Light silty clay	CL to CH	A–7–6(15–19)
		34–50	Silty clay loam	CL to CH	A–7–6(14–18)

See footnotes at end of table.

of the soils

units may have different properties and limitations, and it is necessary to follow carefully the instructions for referring to other series as than; the symbol > means more than]

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
98–100	95–99	60–75	0. 63–2. 0	0. 19	5. 6–6. 0	Moderate.
94–100	92–97	55–75	0. 2–0. 63	. 17	5. 6–6. 0	Moderate.
94–100	92–97	55–75	0. 2–0. 63	. 17	6. 6–7. 3	Moderate.
---	100	95–100	0. 2–0. 63	. 21	6. 1–6. 5	Moderate to high.
---	100	95–100	0. 2–0. 63	. 20	6. 1–6. 5	Moderate to high.
---	100	95–100	0. 2–0. 63	. 18	6. 6–7. 3	Moderate to high.
90–100	80–100	60–80	0. 63–2. 0	. 17	6. 6–7. 3	Moderate.
85–100	80–100	45–75	0. 63–2. 0	. 15	4. 5–5. 0	Moderate.
85–100	80–100	35–60	2. 0–6. 3	. 10	4. 5–5. 0	Low.
---	100	85–100	0. 63–2. 0	. 18	6. 6–7. 3	Moderate.
---	100	85–100	<0. 06	. 12	5. 1–5. 5	High.
---	100	85–100	<0. 06	---	6. 6–7. 3	High.
100	95–100	85–100	0. 2–0. 63	. 18	6. 1–6. 5	Moderate to high.
100	95–100	85–100	<0. 06	. 13	6. 1–6. 5	High.
95–100	90–100	75–90	<0. 06	. 13	6. 6–7. 3	High.
100	100	96–100	0. 2–0. 63	. 21	6. 6–7. 3	High.
100	100	96–100	0. 2–0. 63	. 19	6. 1–6. 5	High.
100	98–100	80–90	<0. 06	. 15	6. 6–7. 3	High.
---	100	95–100	0. 63–2. 0	. 18	5. 6–6. 0	Moderate.
---	100	95–100	0. 02–0. 63	. 16	5. 1–5. 5	Moderate to high.
---	100	95–100	0. 2–0. 63	. 17	5. 1–5. 5	Moderate to high.
100	100	85–100	0. 2–0. 63	. 21	6. 1–6. 5	Moderate to high.
100	100	80–100	0. 2–0. 63	. 19	6. 6–7. 3	High.
---	100	95–100	0. 63–2. 0	. 20	5. 6–6. 0	Moderate.
95–100	85–100	70–100	<0. 06	. 12	4. 5–5. 0	High.
100	95–100	90–100	0. 63–2. 0	. 21	5. 6–6. 0	Moderate to high.
100	95–100	90–100	0. 63–2. 0	. 19	6. 1–6. 5	Moderate to high.
100	95–100	90–100	0. 63–2. 0	. 17	6. 6–7. 3	Moderate to high.
85–100	80–95	55–70	0. 63–2. 0	. 18	5. 6–6. 0	Moderate.
85–100	80–95	60–80	0. 2–0. 63	. 17	5. 6–6. 0	Moderate to high.
85–100	80–95	60–80	0. 2–0. 63	. 16	7. 9–8. 4	Moderate.
100	100	95–100	0. 63–2. 0	. 19	6. 6–7. 3	Moderate.
100	100	95–100	0. 2–0. 63	. 18	5. 1–5. 5	High.
100	100	95–100	0. 2–0. 63	. 18	5. 6–6. 0	Moderate to high.

TABLE 3.—*Estimated properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Gosport: GpE, GpF	>5	0–13	Silt loam	ML–CL to CL	A–6
		13–36	Heavy silty clay loam	CH	A–7–6(16–20)
		36–60	Heavy silty clay loam, shale.	CH	A–7–6(16–20)
Hixton: HxG	>5	0–19	Fine sandy loam	SM or SC	A–2 or A–4
		19–33	Fine sandy loam	SM or SC	A–2 or A–4
		33–48	Weathered sandstone.		
Judson: JuB	3–6	0–28	Light silty clay loam	CL–OL	A–6(9) to A–7–6(13)
		28–52	Silty clay loam	CL	A–6(10) to A–7–6(12)
Kennebec: Ke	[2] 3–5	0–28	Heavy silt loam	CL	A–6(8–12)
		28–52	Heavy silt loam	CL	A–6(8–12)
Kenswick: KkD2	(1)	0–9	Loam to silt loam	CL	A–6(8–12)
		9–37	Clay or heavy clay loam	CH	A–7–6(14–18)
		37–60	Clay loam	CL	A–6(6–12)
Ladoga: LaB, LaB2, LaC, LaC2, LaD, LaD2, LaE2, LbB.	>5	0–10	Silt loam	ML or CL	A–6(10) to A–7–6(14)
		10–47	Heavy silty clay loam	CL	A–7–6(14–16)
		47–60	Silty clay loam	ML or CL	A–6(10) to A–7–6(14)
Lamoni: LcC, LcC2, LcD, LcD2, LcD3	(1)	0–17	Light clay loam	CL	A–6(10) to A–7–6(12)
		17–50	Heavy clay loam	CH	A–7–6(16–20)
		50–60	Clay loam	CL	A–6(10) to A–7–6(15)
Lindley: LdD2, LdE2, LdF, LdG, LeE3	>5	0–9	Loam	CL	A–4(3) to A–6(8)
		9–34	Heavy clay loam	CH	A–7–6(14–16)
		34–60	Clay loam	CL	A–6(10) to A–7–6(14)
Macksburg: MbA, MbB	2–4	0–18	Silty clay loam	ML–CL	A–7–6(11–14)
		18–42	Heavy silty clay loam	CH	A–7–6(17–20)
		42–62	Light silty clay loam	CL	A–7–6(15–19)
Martinsburg: MgB	3–6	0–17	Silt loam	ML–CL	A–6(9)
		17–50	Silty clay loam	CL	A–6(12) to A–7–6(14–17)
*Mystic: MtD2, MyD2, MyE2. For Clanton part of MyD2 and MyE2, see Clanton series.	>5	0–13	Loam or silt loam	CL	A–6(8–12)
		13–46	Heavy clay loam	CL or CH	A–7–6(14–18)
		46–60	Clay loam	CL or CH	A6–(8–12) to A–7–6(11–15)
Nevin: NeA, NeB	2–4	0–17	Light silty clay loam	CL	A–6(9) to A–7–6 (14)
		17–40	Silty clay loam	CL or CH	A–7–6 (12–18)
		40–60	Silty clay loam	CL	A–6(10) to A–7–6(16)
Nira: NlC2	>5	0–12	Light silty clay loam	ML or CL	A–6(8–12)
		12–36	Silty clay loam	CL	A–7–6(10–14)
		36–50	Light silty clay loam	CL	A–6(10) to A–7–6(12)
*Nodaway: Nm, Nn, NoB. For Martinsburg part of NoB, see Martinsburg series.	[2] 3–6	0–60	Silt loam	ML or CL	A–4(8) to A–6 (10)

See footnotes at end of table.

of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
-----	100	85–100	0.63–2.0	0.18	6.1–6.5	Moderate.
-----	100	85–100	0.06–0.20	.16	5.1–5.5	High.
-----	100	85–100	<0.06	-----	6.1–6.5	High.
100	80–90	25–50	2.0–6.3	.12	5.6–6.0	Low.
100	80–90	25–50	2.0–6.3	.10	5.6–6.0	Low.
-----	100	90–100	0.63–2.0	.21	6.6–7.3	Moderate.
-----	100	90–100	0.63–2.0	.19	6.6–7.3	Moderate.
-----	100	90–98	0.63–2.0	.21	6.6–7.3	Moderate.
-----	100	90–98	0.63–2.0	.19	6.6–7.3	Moderate.
95–100	80–95	60–80	0.63–2.0	.17	5.6–6.0	Moderate.
95–100	80–95	65–85	0.06–0.20	.16	4.5–5.0	Moderate to high.
95–100	80–95	65–80	0.2–0.63	.15	7.4–7.8	Moderate.
-----	100	95–100	0.63–2.0	.18	6.1–6.5	Moderate to high.
-----	100	95–100	0.2–0.63	.17	5.6–6.0	Moderate to high.
-----	100	95–100	0.63–2.0	.18	6.1–6.5	Moderate to high.
95–100	95–100	70–95	0.2–0.63	.19	5.6–6.0	Moderate to high.
95–100	95–100	85–100	0.06–0.20	.15	6.1–6.5	High.
85–100	85–100	55–85	0.2–0.63	.16	6.1–6.5	High.
85–95	80–90	55–70	0.63–2.0	.17	4.5–5.0	Moderate.
85–95	80–90	60–80	0.2–0.63	.15	4.5–5.0	High.
85–95	80–90	60–80	0.2–0.63	.16	7.4–7.8	Moderate to high.
-----	-----	96–100	0.63–2.0	.20	5.6–6.0	Moderate to high.
-----	-----	96–100	0.2–0.63	.19	5.1–5.5	High.
-----	-----	96–100	0.2–0.63	.18	5.6–6.0	Moderate to high.
-----	100	80–100	0.63–2.0	.20	6.6–7.3	Moderate.
-----	100	80–100	0.63–2.0	.19	5.1–5.5	Moderate to high.
95–100	90–100	90–95	0.63–2.0	.17	6.6–7.3	Moderate.
90–100	80–100	65–85	0.06–0.63	.15	4.5–5.0	Moderate to high.
85–100	80–100	60–80	0.63–2.0	.14	4.5–5.0	Moderate.
100	95–100	80–100	0.63–2.0	.21	6.1–6.5	Moderate to high.
100	95–100	80–100	0.2–0.63	.20	6.1–6.5	High.
100	95–100	80–100	0.2–0.63	.18	6.6–7.3	Moderate to high.
-----	100	95–100	0.63–2.0	.22	6.6–7.3	Moderate.
-----	100	95–100	0.2–0.63	.19	5.6–6.0	Moderate to high.
-----	100	95–100	0.63–2.0	.17	6.1–6.5	Moderate.
100	95–100	90–100	0.63–2.0	.20	6.6–7.3	Moderate.

TABLE 3.—*Estimated properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification		
			USDA texture	Unified	AASHO
	Feet	*Inches*			
Nordness: NrE	>5	0–12	Loam to silty clay loam	ML–CL	A–6(8–12) to A–7–6(10–14)
		12	Limestone bedrock.		
Olmitz: OmB, OmC	>5	0–23	Loam to light clay loam	CL	A–6(6–10)
		23–55	Light clay loam	CL	A–6(8) or A–7–6(14)
Sharpsburg: SbA, SbB, SbB2, SbC, SbC2, SbD2, ScA, ScB.	>5	0–11	Light silty clay loam	ML–CL	A–6(8–12) to A–7–6(10–14)
		11–36	Heavy silty clay loam	MH or CH	A–7–6(15–20)
		36–52	Silty clay loam	ML–CL or CL	A–7–6(12–16)
*Shelby: ShD2, ShE, ShE2, ShF2, SkE3, SlC2, SlD, SlD2, SlD3, SlE2, SlE3. For Lamoni part of SlC2, SlD, SlD2, SlD3, SlE2, and SlE3, see Lamoni series.	>5	0–11	Heavy loam	CL	A–4(8) to A–6(12)
		11–60	Light to medium clay loam.	CL	A–6(10) to A–7–6(14)
Sloping stony land: SoE. Soil properties are variable.	>5				
Sperry: Sp	0–2	0–10	Silt loam	OL or CL	A–6(8) to A–7–5(12)
		10–40	Silty clay to heavy silty clay loam.	CH	A–7–6(18–20)
		40–60	Heavy silty clay loam	CL or CH	A–7–6(14–17)
Spillville: Sr	[2] 3–5	0–53	Loam	CL or OL	A–6(8) to A–7–5(14)
		53–60	Sandy loam	SM or SC	A–2 or A–4
Spillville, flaggy substratum: Ss	[2] 3–5	0–32	Heavy loam	CL or OL	A–6(8) to A–7–5(14)
		32–46	Flaggy loam	Variable	Variable
Steep rock land: StG. Soil properties are variable.	>5				
Vesser: VeA, VeB	[2] 1–3	0–27	Silt loam	ML or CL	A–6(8–10)
		27–52	Silty clay loam	CH	A–7–6(14–18)
Wabash:					
Wa	[2] 1–3	0–27	Silty clay	OH or CH	A–7–6(18) to A–7–5(20)
		27–52	Heavy silty clay to clay	CH	A–7–6(20)
Wb	[2] 1–3	0–18	Silty clay loam	CH	A–7–6(14–18)
		18–52	Heavy silty clay to clay	CH	A–7–6(20)
Winterset: Wc	1–3	0–19	Light silty clay loam	ML–CL	A–7–6 (10–14)
		19–32	Light silty clay	CH or MH–CH	A–7–6 (16–20)
		32–58	Silty clay loam	CH	A–7–6 (16–20)
Wiota: WoA, WoB	>5	0–29	Silt loam	ML or CL	A–4–8 to A–6 (6–10)
		29–37	Silty clay loam	CL–CH	A–7–6 (14–19)
		37–50	Silty clay loam	CL–CH	A–7–6 (12–19)
Zook: ZoA, ZoB	[2] 1–3	0–18	Silty clay loam	OH or CH	A–7–6 (16) to A–7–5 (20)
		18–60	Heavy silty clay loam to silty clay.	CH	A–7–6 (16–20)

[1] Seasonally wet because of seepage from more permeable soils upslope.

of the soils—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	95–100	75–90	0. 63–2. 0	0. 17	6. 6–7. 3	Moderate.
100	90–100	60–80	0. 63–2. 0	. 18	5. 6–6. 0	Moderate.
100	90–100	60–80	0. 63–2. 0	. 17	5. 6–6. 0	Moderate.
-------------	100	96–100	0. 63–2. 0	. 21	6. 6–7. 3	Moderate to high.
-------------	100	96–100	0. 2–0. 63	. 18	6. 1–6. 5	High.
-------------	100	96–100	0. 63–2. 0	. 19	6. 6–7. 3	Moderate to high.
90–95	80–95	60–80	0. 63–2. 0	. 18	6. 1–6. 5	Moderate.
85–95	80–90	60–80	0. 2–0. 63	. 16	5. 1–5. 5	Moderate to high.
-------------	100	95–100	0. 63–2. 0	. 20	6. 6–7. 3	Moderate.
-------------	100	95–100	<0. 06	. 18	5. 6–6. 0	High.
-------------	100	95–100	0. 2–0. 63	. 16	6. 6–7. 3	Moderate to high.
100	95–100	65–80	0. 63–2. 0	. 20	6. 1–6. 5	Moderate.
100	80–90	25–50	2. 0–6. 3	. 10	6. 1–6. 5	Low.
100	95–100	65–80	0. 63–2. 0	. 20	6. 6–7. 3	Moderate.
Variable	Variable	Variable	Variable	Variable	7. 4–7. 8	Low.
100	100	95–100	0. 63–2. 0	. 18	5. 6–6. 0	Moderate.
100	100	95–100	0. 63–2. 0	. 17	5. 1–5. 5	High.
100	100	95–100	<0. 06	. 15	5. 6–6. 0	High.
100	100	95–100	<0. 06	. 12	5. 6–6. 0	High.
100	100	95–100	0. 2–0. 63	. 18	6. 6–7. 3	Moderate to high.
100	100	95–100	<0. 06	. 12	6. 1–6. 5	High.
-------------	100	95–100	0. 2–0. 63	. 20	6. 6–7. 3	High.
-------------	100	95–100	0. 06–0. 20	. 18	5. 6–6. 0	High.
-------------	-------------	95–100	0. 2–0. 63	. 19	6. 1–6. 5	High.
-------------	100	85–95	0. 63–2. 0	. 20	6. 6–7. 3	Moderate.
-------------	100	85–100	0. 2–0. 63	. 18	5. 6–6. 0	Moderate to high.
-------------	100	85–100	0. 2–0. 63	. 16	5. 6–6. 0	Moderate to high.
-------------	100	90–100	0. 06–0. 20	. 19	6. 6–7. 3	High.
-------------	100	90–100	0. 06–0. 20	. 18	6. 1–6. 5	High.

[2] Subject to flooding.

TABLE 4.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping as indicated]

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Alluvial land: Au	Variable	Variable	Subject to frequent flooding; high water table.	Subject to frequent flooding; high water table.	No suitable sites
Alluvial land, channeled: Av.	Variable	Variable	Subject to frequent flooding; high water table.	Subject to frequent flooding; high water table.	No suitable sites
Arbor: AwD	Good to depth of 34 inches; fair below.	Good: good bearing capacity and shear strength; slight compressibility and good workability and compaction below the surface layer.	Good source of embankment material below the surface layer; rolling topography.	Good bearing capacity and shear strength; slight compressibility; generally deep to the seasonal high water table.	Moderately slowly permeable when uncompacted; occasional sand pockets and stones.
Bremer: Br	Good to depth of 17 inches; fair below: high clay content.	Very poor: poor bearing capacity; high expansion potential; difficult to compact above or below optimum moisture content.	Low borrow potential; seasonal high water table; high in organic-matter content in upper 2 feet; subject to occasional flooding.	High compressibility; seasonal high water table; subject to dangerous expansion if initially dry.	Low permeability when compacted; nearly level.
*Caleb: CbD2, CeD2, CeE2. For Mystic part of CeD2 and CeE2, see Mystic series.	Fair: somewhat low in fertility.	Good: fair to good bearing capacity and shear strength; low compressibility; easily compacted to high density; small volume change.	Some cuts may be seasonally seepy; low organic-matter content in surface layer; high need for cuts and fills; difficult to vegetate cuts.	Good bearing capacity and shear strength; low compressibility; uneven consolidation.	Low permeability when compacted but coarse strata may be encountered below 4 feet.
*Clanton: ClD2, ClF2, CmD2, CmE2, CmF2, CmG2. For Gosport part of CmD2, CmE2, CmF2, and CmG2, see Gosport series.	Fair to depth of 11 inches; poor below 11 inches: low fertility and high clay content.	Very poor in subsoil and substratum: poor shear strength; high shrink-swell potential.	Borrow often wet and seepy; land slides of natural soil or road fills over the sloping shale likely.	Poor shear strength and bearing capacity; high compressibility and shrink-swell potential; seasonal high water table.	Low permeability; occasionally mixed with sandstone that may need a seal blanket.
Clarinda: CnC, CnC2	Fair to depth of 16 inches; poor below 16 inches: high clay content; low natural fertility.	Very poor: highly elastic; high volume change with change in moisture content; low bearing capacity when wet; low stability at high moisture content; difficult to compact properly.	Low borrow potential; seepage often occurs in cuts; high in organic-matter content in surface.	Poor shear strength; fair to poor bearing capacity; high shrink-swell potential; uneven consolidation.	Very low permeability when compacted.

interpretations

units may have different properties and limitations, and it is necessary to follow carefully the instructions for referring to other series

Soil features affecting—Continued					Limitations for septic tank filter fields
Farm ponds—Cont.: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Variable soil properties; not used for embankments because of position.	Adequate outlets commonly difficult to obtain; land leveling and flood prevention needed.	Subject to frequent flooding; variable soil properties.	Not needed because of topography.	Not needed because of topography.	Severe: subject to frequent flooding; high water table.
Variable soil properties; not used for embankments because of position.	Adequate outlets commonly difficult to obtain; land leveling and flood prevention needed.	Subject to frequent flooding; variable soil properties.	Not needed because of topography.	Not needed because of topography.	Severe: subject to frequent flooding; high water table.
Good stability; slow permeability when compacted; material below the surface layer is good for impervious cores and blankets; good resistance to piping.	Not needed	Subject to runoff and erosion; high available water capacity.	Soil properties are favorable.	Soil properties are favorable.	Moderate to severe: moderately slow permeability; slopes complicate layout and construction in places.
Fair stability; high organic-matter content in upper 2 feet; poor workability when wet; highly compressible; high volume change with increased moisture content.	Tile drains satisfactory in most areas; surface drains or closer tile spacings are beneficial where moderately slow permeability is a limitation.	High available water capacity; moderately slow intake rate; tile needed before irrigating.	Terraces not needed; diversions intercept overflow from adjacent slopes.	Not needed because of topography.	Severe: seasonal high water table; moderately slow permeability.
Good stability; easily compacted to high density; low volume change.	Drainage not generally needed; some areas are seepy after heavy rains.	Moderate available water capacity; moderate intake rate; low potential for farming.	Slopes over 12 percent common; low fertility in subsoil.	Tile needed in places to control seepage; low fertility; difficult to vegetate.	Moderate: slopes commonly over 8 percent; poor filtering material below depth of 4 feet.
Clayey subsoil and shaly substratum; high shrink-swell potential; may tend to creep in embankments; low permeability.	Not needed	Not needed because of steep slopes and low potential for farming.	Low for potential farming; clayey infertile subsoil.	Difficult to vegetate; clayey subsoil is low in fertility.	Very severe: very slow permeability in subsoil and substratum.
Fair stability on flat slopes; high volume change; moderate compressibility.	Very slow permeability; location of interceptor tile is critical to get adequate drainage.	Slow intake rate and very slow permeability; low potential for farming.	Low fertility; subsoil is difficult to vegetate where exposed during terrace construction; diversions properly placed are beneficial.	Difficult to vegetate where subsoil is exposed; topdressing commonly required.	Severe: very slowly permeable; seasonal high water table.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Clearfield: CoC, CoC2	Fair to depth of 12 inches; poor below 12 inches: high clay content.	Very poor: high compressibility; fair to poor compaction characteristics; high shrink-swell potential; seasonal high water table; clayey substratum should not be placed in embankments.	Wet and seepy: seasonal high water table; very poor source of embankment material.	Fair bearing capacity; poor shear strength; high compressibility; seasonal high water table; seasonally seepy and wet.	Sites suitable for reservoir areas are seldom available.
Clinton: CsB, CsC, CsC2, CsD2, CtB.	Fair to depth of 9 inches; low organic-matter content; poor below 9 inches: high clay content.	Poor to fair: poor shear strength with fair bearing capacity; moderate to high shrink-swell potential; narrow range of optimum moisture content for satisfactory compaction.	Rolling topography; high moisture content in deep cuts likely; low density; low borrow potential; uniform material.	Poor shear strength; fair bearing capacity; moderate compressibility but uniform consolidation.	Low permeability when compacted; low seepage rates; good sites generally available.
*Colo: Cu, Cv, CwB, CyB. For Ely part of CwB and CyB, see Ely series.	Good to depth of 18 inches; fair below: high clay content.	Very poor: poor bearing capacity and shear strength; seasonal high water table; highly compressible; high in organic-matter content to about 3 feet or more.	Seasonal high water table; generally subject to some flooding; poor foundations for high fills.	Seasonal high water table; generally subject to some flooding; high compressibility with uneven consolidation.	High in organic-matter content; some areas have potential for dug-out ponds.
Dunbarton: DbD2	Fair to 15 inches: low organic-matter content; poor below 15 inches: high clay content.	Very poor: clay subsoil; highly plastic and large volume change when wet; elastic substratum; excellent limestone.	24 to 36 inches to limestone; limestone hard and level bedded; poor borrow potential; surface moderately high in organic-matter content.	All features favorable where footing rests on the limestone.	Compacted seal blanket needed over limestone; limestone is fractured and too porous to hold water.
Ely: ElB	Good to 18 inches; fair below 18 inches: high clay content.	Poor: moderate to high volume change and loss of bearing capacity when wet; difficult to compact.	High organic-matter content; seasonally high water table; subject to local flooding for short duration.	Fair to poor bearing capacity; moderate to high compressibility; subject to local flooding for short duration.	Reservoir bottom should be scarified and compacted; coarse-textured layer may be encountered below depth of 4 feet.
Flaggy alluvial land: Fg.	Not suitable: many rock fragments on surface and throughout.	Very poor: many rock fragments on surface and throughout.	Subject to frequent flooding; many rock fragments.	Subject to frequent flooding.	Generally not suitable; many rock fragments throughout; underlain by bedrock.
Gara: GaC2, GaD2, GaE, GaE2, GaF2, GaG.	Fair to depth of 11 inches: low in organic matter; poor below 11 inches: high in clay content.	Good: fair to good bearing capacity; good workability and compaction; easily compacted to high density.	Rolling topography; variable materials in cuts; some cuts may be seepy; good borrow potential.	Good bearing capacity and shear strength; low compressibility; uneven consolidation.	Low permeability when compacted; good sites generally available.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds—Cont.	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations for septic tank filter fields
Embankment					
Fair stability on flat slopes; poor compaction and workability; high expansion potential; often wet and seepy with a high water table.	Very slow permeability below a depth of 35 to 45 inches; interceptor tile are needed; placement is critical.	Slow intake rate; high available water capacity; wetness is generally a limitation.	Wetness and high water table commonly hinder construction; artificial drainage is needed.	Seepage and high water table commonly hinder construction; artificial drainage is needed.	Severe: very slow permeability; seepy with a seasonal high water table.
Fair stability; poor compaction above optimum moisture content and fair at or below.	Not needed	Moderate intake rate; high available water capacity; erosion control needed on slopes of 3 percent and above.	Cuts should be held to a minimum to prevent exposure of less productive subsoils.	Tile needed along side to prevent seepage so that vegetation can be established.	Moderate: moderately slow permeability.
High in organic-matter content in the top 3 feet or more; poor embankment foundation.	Subject to flooding and seasonal high water table; tile function satisfactory.	Medium intake rate; high available water capacity; commonly needs artificial drainage; generally subject to some degree of flooding.	Not needed because of topography.	Not needed because of topography.	Severe: seasonal high water table; generally subject to some degree of flooding; moderately slow permeability.
Fair to good stability; shallow to limestone; some settlement can be expected if large fragments are used in fills.	Not needed	Low available water capacity; moderate intake rate; requires frequent application of water.	Limestone bedrock hinders construction; cuts should be held to a minimum.	Difficult to establish vegetation where bedrock is shallow.	Severe: Limestone encountered at depth of 30 inches; and very slowly permeable layer above the limestone.
Adequate strength and stability; moderate to high expansion potential; good compaction at or near optimum moisture content.	Wetness due to seepage; use interceptor tile where needed.	Moderate intake rate; high available water capacity; high potential for farming.	Not needed because of topography; diversions intercept overflow.	Tile needed to prevent seepage so that vegetation can be established.	Moderate to severe: seasonal high water table.
High organic-matter content; many rock fragments.	Subject to frequent flooding; many rock fragments throughout.	Not suitable as cropland; subject to flooding.	Not needed	Many rock fragments throughout.	Severe: subject to frequent flooding; many rock fragments throughout.
Adequate stability; easily compacted to high density; good workability; good for cores.	Not needed	Subject to high rate of runoff; high available water capacity; erosion control practices needed.	Suitable on slopes of less than 12 percent; cuts should be held to a minimum because of less productive subsoils.	Tile needed to keep waterway dry so that vegetation can be established.	Moderate: on slopes less than 9 percent; moderately slow permeability.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Givin: Gn, Go	Fair to depth of 11 inches: low in organic matter; poor below 11 inches: high clay content.	Very poor: low bearing capacity when wet; poor shear strength; large volume change; difficult to compact to high density; narrow range of moisture content for satisfactory compaction.	Seasonally high water table; low borrow potential; poor workability when wet; nearly level topography.	Moderate to high compressibility; uniform consolidation; seasonal high water table; saturation may cause loss of cohesion, resulting in settlement.	Good sites unlikely; low permeability when compacted.
Gosport: GpE, GpF	Fair to depth of 13 inches; poor below 13 inches: low fertility.	Very poor in the subsoil; unsuitable in the substratum: poor shear strength; high shrink-swell potential.	Borrow often wet and seepy; landslides of natural soil or road fill over the sloping shale likely.	Poor shear strength and bearing capacity; high compressibility and shrink-swell potential; seasonal high water table.	Low permeability; occasionally mixed with sandstone that may need a seal blanket.
Hixton: HxG	Fair to depth of 19 inches: low in organic matter; poor below 19 inches: low fertility.	Good: good bearing capacity; low compressibility; small volume change with moisture content.	Good borrow potential above the sandstone; somewhat erodible.	Low compressibility; good shear strength; small volume change with change in moisture content.	Material too porous to hold water.
Judson: JuB	Good to depth of 52 inches.	Poor: high in organic-matter content upper 2 or 3 feet; low bearing capacity when wet; difficult to compact to high density.	Subject to local runoff; may have seepy areas in some places; low borrow potential; high in organic-matter content.	High compressibility; fair bearing capacity and shear strength; subject to local runoff from higher areas.	Reservoir bottom should be scarified and compacted; some seepage can be expected.
Kennebec: Ke	Good to depth of 52 inches.	Fair to poor: medium to high in organic-matter content in top 2 feet; fair to poor bearing capacity; high compressibility.	Subject to flooding; medium to high in organic-matter content in top 2 to 3 feet; poor foundation for high fills.	Fair to poor bearing capacity; fair shear strength; subject to flooding; and occasional water table above depth of 4 feet may occur.	Not used for reservoirs, because of topography and position.
Keswick: KkD2	Fair to depth of 9 inches: low in organic matter; poor below 9 inches: low fertility; high clay content.	Poor to depth of about 4 feet; good in substratum: elastic; moderate to high shrink-swell potential; substratum high density materials; good workability and compaction.	Rolling topography; may have seepage in some cuts; high susceptibility to frost action where sand pockets occur.	Low compressibility; good bearing capacity below 4 feet; highly expansive if subject to wide fluctuation in moisture content.	Low permeability; seepage will be low.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds—Cont. Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations for septic tank filter fields
Low stability when wet; moderate to high shrink-swell potential; high compressibility; narrow range of moisture content for satisfactory compaction.	Moderately slow permeability; seasonal high water table; occasional depressional areas; tile drains satisfactory.	High available water capacity; requires tile drainage before irrigation.	Not needed because of topography.	Not needed because of topography.	Severe unless tile drained: seasonal high water table; moderately slow permeability.
Clayey subsoil and shaly substratum; high shrink-swell potential and tendency to creep in embankment; low permeability and and high shrink-swell potential.	Not needed	Not needed because of steep slopes and low potential for farming.	Low potential for farming; clayey infertile subsoil.	Difficult to vegetate; clayey subsoil is low in fertility and strongly acid.	Very severe: very slow permeability in the soil and substratum.
Pervious; high stability and low volume change; susceptible to piping.	Not needed	Not needed because of steep slopes and low potential for farming.	Low potential for farming and sandy infertile subsoil.	Difficult to vegetate; sandy subsoil is low in fertility.	Very severe: slopes exceed 9 percent; underlain with sandstone.
Fair stability; high compressibility; moderate expansion potential; difficult to compact except at optimum moisture content.	Drainage not needed except in occasional seepage areas; use interceptor tile.	High available water capacity; moderate intake rate; high potential for farming.	Terraces generally not needed; diversions intercept local overflow.	Tile helpful to control seepage so that vegetation can be established.	Slight to moderate: periodic flooding can cause damage to filter field.
Medium to high in organic-matter content to depth of 2 or 3 feet; fair stability and fair compaction in the material below the surface layer; poor embankment foundation.	Subject to flooding	High available water capacity; medium intake rate; subject to flooding.	Not needed because of topography and position.	Generally not needed; no soil limitations.	Moderate to severe: subject to flooding; a high water table may occasionally occur.
Fair to good stability; generally good for impervious cores; moderate to high shrink-swell potential; good compaction at or near optimum moisture content; low compressibility.	Slowly permeable layer causes seepage; interceptor tile needed.	High available water capacity; slow permeability; subject to runoff and erosion; low potential as cropland.	Unfavorable subsoil in most places; terrace channel can be wet and seepy; cuts should be held to a minimum; slopes commonly exceed 12 percent.	Tile needed to control seepage so that good vegetation can be established.	Severe: slow permeability; seasonally wet and seepy.

454-418—74——7

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Ladoga: LaB, LaB2, LaC, LaC2, LaD, LaD2, LaE2, LbB.	Fair to depth of 9 inches: low in organic-matter content; poor below 9 inches: high clay content.	Fair to poor: fair bearing capacity; poor shear strength; moderate to high shrink-swell potential; difficult to compact to high density; narrow range of moisture content for suitable compaction.	Rolling topography; high moisture content in some deep cuts.	Fair bearing capacity; poor shear strength; moderate compressibility; uniform consolidation.	Uniform material; low permeability when compacted.
Lamoni: LcC, LcC2, LcD, LcD2, LcD3.	Fair to depth of 17 inches; poor below 17 inches: high clay content and low fertility.	Poor: elastic; high volume change with change in moisture content; difficult to compact properly; low stability at high moisture content.	Seasonal high water table; moderately high in organic-matter content; often high moisture content in cuts; poor borrow potential.	Very expansive when subjected to wide fluctuation in moisture content; fair bearing capacity; uneven consolidation.	Good; very low permeability when compacted.
Lindley: LdD2, LdE2, LdF, LdG, LeE3.	Fair to depth of 9 inches: low in organic-matter content; poor below 9 inches: high clay content.	Good: fair to good bearing capacity; low compressibility; easily compacted to high density; moderate volume change with change in moisture content.	Rolling and steep topography; good source of borrow; some cuts may be seepy; low organic-matter content in surface.	Fair to good bearing capacity and shear strength; low compressibility; uneven consolidation.	Good sites likely; low permeability.
Macksburg: MbA, MbB.	Fair to depth of 18 inches: high clay content; poor below 18 inches: high clay content.	Poor to very poor: fair to poor bearing capacity and poor shear strength; high shrink-swell potential; high compressibility.	Very poor source of borrow; high in organic-matter content to depth of about 1½ feet.	Fair to poor bearing capacity; high compressibility; high shrink-swell potential.	Not normally used for reservoirs, because of topography; moderately slow to moderate uncompacted permeability.
Martinsburg: MgB----	Fair to good to depth of 23 inches: low in organic-matter content; fair below 23 inches: high clay content.	Poor: large volume change and loss of bearing capacity when wet; difficult to compact to high density; very narrow range of moisture content for satisfactory compaction.	Subject to local runoff: may have seepy areas in some places; low borrow potential; moderately high in organic-matter content.	High compressibility; fair bearing capacity and shear strength; subject to local runoff from higher areas.	Reservoir bottom should be scarified and compacted; some seepage can be expected.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds—Cont.	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations for septic tank filter fields
Embankment					
Low stability when wet; poor compaction above optimum moisture content; low permeability when compacted; moderate to high shrink-swell potential.	Not needed	Moderate intake rate; high available water capacity; erosion control practices needed.	Suitable on slopes of less than 12 percent.	Tile generally needed to control seepage so that vegetation can be established.	Slight to moderate on slopes of less than 9 percent; slopes commonly exceed 9 percent.
Fair to good stability on flat slopes; impervious when compacted; suitable for cores; high expansion potential.	Slowly permeable layer; interceptor tile needed upslope.	Slow intake rate and slow permeability; low potential for farming.	Low fertility in subsoil; where clayey, subsoil is difficult to vegetate if exposed.	Difficult to vegetate where subsoil is exposed; topdressing commonly required.	Severe: slow permeability; seasonally wet and seepy.
Good stability; easily compacted to high density; usable for core material; low permeability when compacted; good workability.	Not needed	High available water capacity; subject to high rate of runoff and erosion; low natural fertility.	Slopes generally exceed 12 percent and commonly are irregular and steep.	Difficult to vegetate; tile commonly needed to control seepage.	Severe: slopes exceed 9 percent; moderately slow permeability in subsoil.
Fair to poor stability; high compressibility; high shrink-swell potential; low compacted permeability.	Would benefit from tile drainage in years when water table is high.	High available water capacity; medium to slow intake rate; a good soil for farming.	Not needed because of topography.	Soil properties are favorable.	Moderate: moderately slow permeability; in some areas the water table is occasionally above depth of 4 feet.
Fair stability; high compressibility; moderate expansion potential; difficult to compact except at optimum moisture content.	Not needed	High available water capacity; medium intake rate; subject to erosion and gullying.	Soil properties are favorable.	Soil properties are favorable.	Slight: moderate permeability.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
*Mystic: MtD2, MyD2, MyE2. For the Clanton part of MyD2 and MyE2, see Clanton series.	Fair to depth of 13 inches: low in organic-matter content; poor below 13 inches: high clay content; low fertility.	Fair to poor in subsoil: low bearing capacity when wet; large volume change with moisture content; good in substratum; small volume change with moisture content; easily compacted to high density.	Fair to good borrow potential; high moisture content in some cuts; susceptible to frost action; seasonally wet and seepy; difficult to vegetate cuts.	Good bearing capacity in substratum; subject to frost heave and loss of bearing capacity on thawing.	Low permeability when compacted; coarse textured strata may be encountered below depth of 4 to 5 feet.
Nevin: NeA, NeB	Good to depth of 17 inches; fair below 17 inches: high clay content.	Poor: poor bearing capacity and fair shear strength; large volume change with change in moisture content; elastic and difficult to compact properly.	Nearly level topography; high in organic-matter content; seasonal high water table; low borrow potential.	Moderate to high compressibility; poor bearing capacity; subject to occasional flooding; seasonal high water table.	Suitable sites unlikely; low permeability when compacted; fluctuation of water table.
Nira: NlC2	Good to depth of 12 inches; fair below 12 inches: high clay content.	Fair to poor: moderate volume change and very low bearing capacity when wet; difficult to compact to high density.	Low borrow potential; high moisture content can often be expected in cuts.	Highly compressible; subject to frost heave; low bearing capacity.	Commonly too high in the landscape for suitable sites; low permeability when compacted.
*Nodaway: Nm, Nn, NoB. For Martinsburg part of NoB, see Martinsburg series.	Fair: may be hard to stabilize where slopes are steep.	Poor: low bearing capacity and moderate volume change when wet; low stability when wet; difficult to compact to high density.	Nearly level topography; subject to frequent flooding.	High compressibility; subject to frequent flooding; low bearing capacity.	Reservoir area needs to be compacted; some seepage can be expected.
Nordness: NrE	Fair to depth of 12 inches; limestone fragments; poor below 12 inches: limestone bedrock.	Very poor: 15 inches or less to limestone bedrock.	High need for cuts and fills; limestone hard and level bedded.	All features favorable where footing rests on bedrock.	15 inches or less to fractured bedrock.
Olmitz: OmB, OmC	Good to depth of 55 inches.	Poor: high in organic-matter content to depth of 2 to 3 feet; fair to poor bearing capacity; moderate shrink-swell potential.	High in organic-matter content to depth of 2 to 3 feet; poor source of embankment material; fair source in substratum.	Fair to poor bearing capacity; fair shear strength; medium compressibility; moderate shrink-swell potential.	Seldom used for reservoir areas because of position on the landscape.

interpretations—Continued

Soil features affecting—Continued					Limitations for septic tank filter fields
Farm ponds—Cont.	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	
Embankment					
Good stability; semi-impervious to impervious when compacted; good workability; low compressibility.	Generally not needed, but interceptor tile properly placed can reduce seepy conditions.	Moderate to high available water capacity; slowly permeable subsoil; low potential for farming.	Low fertility in subsoil; tilth poor where subsoil is exposed.	Generally not needed because of their position on the landscape.	Severe: slowly permeable subsoil; poor filtering material below depth of 5 feet.
Fair stability; poor compaction above optimum moisture content; moderate to high shrink-swell potential; high compressibility.	Generally not needed.	Moderate intake rate; high available water capacity; high potential for farming.	Not needed because of topography; diversions properly placed intercept local runoff and reduce wetness and siltation.	Not needed because of topography.	Moderate to severe: seasonal high water table.
Low stability when wet; poor workability above or below optimum moisture content; highly compressible.	Generally not needed except where small seeps are a limitation; interceptor tile will control seepage.	High available water capacity; subject to erosion.	Suitable on slopes of less than 12 percent; terraces can increase seepage unless carefully placed and constructed.	Tile needed to control seepage so that vegetation can be established.	Moderate: moderately slow permeability.
Low stability at high moisture content; poor compaction above optimum moisture content; suitable for shell but not for core; expansion potential moderate; poor resistance to piping.	Subject to flooding	Moderate intake rate; high available water capacity; subject to flooding.	Not needed because of topography.	Tile may be needed to control seepage so that vegetation can be established.	Severe: subject to frequent flooding.
15 inches or less to bedrock.	Not needed	Very low available water capacity; very shallow to bedrock; low potential for farming.	Bedrock at depth of 15 inches or less.	Less than 15 inches to bedrock.	Very severe: 15 inches or less to limestone bedrock.
High in organic-matter content to depth of 2 to 3 feet; fair stability; fair to poor workability and compaction; medium to high compressibility.	Not needed	High available water capacity; medium intake rate; subject to erosion and gullying.	Soil properties are favorable.	Soil properties are favorable.	Slight: moderate permeability.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Sharpsburg: SbA, SbB, SbB2, SbC, SbC2, SbD2, ScA, ScB.	Good to depth of 11 inches; fair below 11 inches: high clay content.	Poor: fair to poor bearing capacity; high shrink-swell potential; medium to high compressibility; difficult to compact to high density.	Poor source of borrow; rolling topography.	Fair to poor bearing capacity and shear strength; high shrink-swell potential.	Scarify and compact reservoir bottom.
*Shelby: ShD2, ShE, ShE2, ShF2, SkE3, SlC2, SlD, SlD2, SlD3, SlE2, SlE3. For Lamoni part of SlC2, SlD, SlD2, SlD3, SlE2, SlE3, see Lamoni series.	Good to depth of 11 inches; fair below 11 inches: high clay content.	Good: fair to good bearing capacity; low compressibility; good workability and compaction; easily compacted to high density.	Rolling topography; variable material in cuts; some cuts may be seepy; good borrow potential.	Good bearing capacity and shear strength; low compressibility; uneven consolidation.	Low permeability when compacted; good sites generally available.
Sloping stony land: SoE.	Not suitable: many rock fragments.	Variable	Variable soil materials with bedrock fragments; slopes to 18 percent.	Variable soil material.	Suitable sites not generally available.
Sperry: Sp	Good to depth of 10 inches; poor below 10 inches: high clay content.	Very poor: large loss of bearing capacity and high volume change when wet; difficult to compact properly; moderate to high compressibility.	Depressional topography; high water table; moderately high organic-matter content in surface; individual areas 1 to 2 acres in size; no borrow potential.	Poor bearing capacity; moderate to high compressibility; uniform consolidation; high water table.	Suitable sites unlikely; low permeability when compacted.
Spillville: Sr	Good to depth of 53 inches.	Fair to poor: moderate volume change and loss of bearing capacity when wet; high to medium in organic-matter content; low density material.	Subject to flooding; medium to high in organic-matter content in upper 3 to 4 feet.	Subject to flooding; fair bearing capacity and shear strength; moderate compressibility.	Suitable sites unlikely; subject to flooding.
Spillville, flaggy substratum: Ss.	Good to depth of 32 inches.	Poor: high to medium organic-matter content; flaggy in the substratum.	Subject to flooding; medium to high in organic-matter content.	Subject to flooding; fair bearing capacity and shear strength; moderate compressibility.	Suitable sites unlikely; subject to flooding.
Steep rock land: StG	Not suitable	Not suitable	Steep; rocky	Steep slopes	No suitable sites

interpretations—Continued

Soil features affecting—Continued						Limitations for septic tank filter fields
Farm ponds—Cont. Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways		
Fair to poor stability; fair to poor compaction characteristics; high shrink-swell potential.	Not needed	High available water capacity; medium intake rate; subject to runoff and erosion.	Soil properties are favorable.	Soil properties are favorable.		Slight to moderate: moderate to moderately slow permeability.
Adequate stability; easily compacted to high density; good workability; suitable cores.	Seepage at loess-till contact can be controlled by interceptor tile; otherwise drainage not needed.	High available water capacity; erosion control practices needed.	Cuts should be held to a minimum because of less productive subsoil.	Tile needed to keep waterway dry so that vegetation can be established.		Moderate on slopes of less than 9 percent, severe on slopes greater than 9 percent: moderately slow permeability.
Many rock fragments; variable soil properties.	Not suitable as cropland.	Not suitable	Many rocky fragments; not cropland.	Many rock fragments.		Severe: many rock fragments; variable depths to bedrock; variable soil properties.
Low stability when wet; moderately high shrink-swell potential; poor workability when wet; moderate to high compressibility.	Very slowly permeable layer; tile may not drain all areas; some areas slightly depressed will benefit from surface drains.	High available water capacity; soil requires drainage before irrigating.	Not needed because of topography.	Not needed because of topography.		Severe: high water table; slowly permeable.
Moderate stability; semipervious; moderate volume change; poor resistance to piping.	Subject to flooding	High available water capacity; may need flood protection; high agricultural potential.	Not needed because of topography; diversions properly placed intercept local runoff and siltation.	Not needed		Moderate to severe: subject to flooding.
Flaggy in substratum; medium to high in organic-matter content.	Subject to flooding; flaggy substratum.	Medium available water capacity; may need flood protection.	Not needed because of topography.	Not needed		Severe: subject to flooding; flaggy limestone in substratum.
Not suitable	Steep; rocky	Steep; rocky	Steep; rocky	Steep; rocky		Not applicable.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—		
	Topsoil	Road fill	Highway location	Foundations for low buildings	Farm ponds: Reservoir area
Vesser: VeA, VeB	Good to depth of 27 inches; poor below 27 inches: high clay content.	Poor: low bearing capacity when wet; poor shear strength; large volume change; difficult to compact to high density; narrow range of moisture content for satisfactory compaction.	Seasonally high water table; low borrow potential; poor workability when wet; nearly level topography.	Moderate to high compressibility; uniform consolidation; seasonal high water table; saturation may cause loss of cohesion resulting in settlement.	Good sites unlikely; low permeability when compacted.
Wabash: Wa	Poor: high clay content.	Very poor: poor bearing capacity; very high volume change with change in moisture content; elastic; difficult to compact; narrow range of moisture content for suitable compaction.	High organic-matter content in surface layer; high water table; subject to flooding; low borrow potential; large settlements under embankments.	Poor bearing capacity and shear strength; medium to high compressibility; subject to very dangerous expansion if initially dry.	Suitable sites unlikely; may be suitable for dug-out ponds; subject to flooding; very slowly permeable.
Wb	Poor: high clay content.	Very poor: poor bearing capacity; very high volume change with change in moisture content; elastic; difficult to compact; narrow range of moisture content for suitable compaction.	High organic-matter content in surface layer; high water table; subject to flooding; low borrow potential; large settlements under embankments.	Poor bearing capacity and shear strength; medium to high compressibility; subject to very dangerous expansion if initially dry.	Suitable sites unlikely; may be suitable for dug-out ponds; subject to flooding; very slowly permeable.
Winterset: Wc	Fair to depth of 19 inches: high clay content; poor below 19 inches: high clay content.	Very poor: poor bearing capacity; difficult to compact to high density; high in organic-matter content to depth of 1½ to 2 feet; seasonally high water table.	Level topography; seasonal high water table; unsuitable as source of borrow material.	Fair to poor bearing capacity; high compressibility; high shrink-swell potential; seasonal high water table.	Not suitable for conventional pond sites; some areas may have potential for dug-out ponds.
Wiota: WoA, WoB	Good to depth of 18 inches; fair below 18 inches: high clay content.	Poor: moderately high volume change and loss of bearing capacity when wet; difficult to compact to high density.	Nearly level to gently sloping topography; low borrow potential; high organic-matter content in surface layer.	High compressibility; fair bearing capacity; if initially dry, subject to high expansion potential.	Suitable sites unlikely; reservoir bottom should be scarified and compacted; some areas too porous to hold water.
Zook: ZoA, ZoB	Poor: high clay content.	Very poor: subject to extremely high volume change and loss of bearing capacity when wet; highly elastic; difficult to compact properly.	Level to depressed topography; high organic-matter content in upper layers; high water table; unsuitable for borrow material; large settlements under embankments.	Poor bearing capacity and shear strength; medium to high compressibility; high water table; subject to dangerous shrinkage on drying.	Suitable sites unlikely; level to depressed topography; subject to flooding; very low permeability.

interpretations—Continued

Soil features affecting—Continued					
Farm ponds—Cont.: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Limitations for septic tank filter fields
Low stability when wet; moderate to high shrink-swell potential; high compressibility; narrow range of moisture content for satisfactory compaction.	Moderately permeable; tile will function.	High available water capacity; requires tile drainage before irrigation.	Not needed because of topography.	Not needed because of topography.	Severe unless tile drained: seasonal high water table; moderate permeability.
Impervious; fair stability on flat slopes; poor compaction and workability; high shrink-swell potential.	Very slow permeability; tile will not function; surface ditches across dominant slopes are beneficial.	Water intake rate varies with amounts of vertical cracking; medium available water capacity; very slowly permeable; difficult to obtain suitable drainage.	Not needed because of topography.	Not needed because of topography.	Very severe: very slow permeability; high water table.
Impervious; fair stability on flat slopes; poor compaction and workability; high shrink-swell potential.	Very slow permeability below a depth of 15 inches; tile will not function properly; surface ditches across dominant slopes are beneficial; subject to flooding.	Water intake rate is moderately slow; medium available water capacity; very slowly premeable below a depth of 15 inches; difficult to obtain suitable drainge.	Not needed because of topography.	Not needed because of topography.	Very severe: very slow permeability; high water table.
High in organic-matter content to depth of 1½ to 2 feet; fair stability but poor compaction characteristics below; low compacted permeability.	Slowly permeable; tile function satisfactory.	High available water capacity; slow intake rate; artificial drainage is generally needed for best plant growth.	Not needed because of topography.	Generally not neeed because of topography; sometimes wet for earth moving.	Severe: seasonal high water table; moderately slow to slow permeability.
Fair stability; moderate to high shrink-swell potential; high compressibility.	Not needed	Moderate intake rate; high available water capacity; high potential for farming.	Terrace construction difficult because of shapes of slopes; diversions properly placed intercept runoff from uplands.	Soil features favorable.	Slight: moderate permeability.
Impervious stability when wet; poor compaction and workability; high shrink-swell potential.	Slow permeability; tile may not drain all areas satisfactorily; proper spacing and depth important; subject to flooding.	Intake rate varies with amount of vertical cracking; high available water capacity; requires drainage before irrigation.	Not needed because of topography; diversions properly placed can improve wetness and reduce siltation.	Not needed because of topography.	Very severe: slowly permeable; subject to flooding.

TABLE 5.—*Engineering*

[Tests for all but the Sharpsburg soil performed by the Iowa State Highway Commission in accordance with procedures of the American

Soil name and location	Parent material	Report No.	Depth	Moisture-density [1]		Mechanical analysis [2]		
						Percentage passing sieve—		
				Maximum dry density	Optimum moisture	¾-in.	⅜-in.	No. 4 (4.7 mm.)
			Inches	*Lb. per cu. ft.*	*Percent*			
Gara loam:								
175 feet south and 780 feet east of NW. corner, sec. 29, T. 75 N., R. 28 W.	Kansan till.	AAD7-2802	0-7	107	13	100	99	99
		AAD7-2803	25-32	103	18	--------	--------	100
		AAD7-2804	38-50	109	16	--------	--------	100
Macksburg silty clay loam:								
783 feet west and 39 feet north of SE. corner, sec. 31, T. 76 N., R. 28 W.	Wisconsin loess.	AAD7-2811	0-6	92	24	--------	--------	--------
		AAD7-2812	24-30	94	24	--------	--------	--------
		AAD7-2813	42-62	101	21	--------	--------	--------
Nevin silty clay loam:								
2,200 feet east and 220 feet north of SW. corner, sec. 11, T. 75 N., R. 28 W.	Alluvium.	AAD7-2808	0-8	91	18	--------	--------	--------
		AAD7-2809	17-29	102	19	--------	--------	--------
		AAD7-2810	29-40	103	19	--------	--------	--------
Sharpsburg silty clay loam:								
NE¼ sec. 4, T. 74 N., R. 27 W.; 2.5 miles NW. of Peru.	Loess.	S30912	0-8	98	20	--------	--------	--------
		S30913	16-30	98	22	--------	--------	--------
		S30914	38-44	104	21	--------	--------	--------
Winterset silty clay loam:								
450 feet north of road center and 25 feet west of SE. corner, SW¼NE¼ sec. 4, T. 75 N., R. 28 W.	Wisconsin loess.	AAD7-2814	0-7	95	21	--------	--------	--------
		AAD7-2815	24-28	92	25	--------	--------	--------
		AAD7-2816	56-75	99	19	--------	--------	--------
Wiota silt loam:								
680 feet north and 95 feet west of SE. corner, NE¼SE¼ sec. 36, T. 76 N., R. 27 W.	Alluvium.	AAD7-2805	0-7	100	19	--------	--------	--------
		AAD7-2806	18-29	100	20	--------	--------	--------
		AAD7-2807	29-37	95	19	--------	--------	--------

[1] Based on method described in Moisture-density Relations of Soils Using a 5.5-lb. Rammer and a 12-in. Drop, AASHO Designation T 99-57 Method A (*1*).

[2] Mechanical analyses according to the AASHO Designation T 88. 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

test data

Association of State Highway Officials (AASHO); tests for the Sharpsburg soil were performed by the U.S. Bureau of Public Roads]

Mechanical analysis [2]—Continued								Liquid limit	Plasticity index	Specific gravity	Classification	
Percentage passing sieve—Con.			Percentage smaller than—									
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.	0.001 mm.				AASHO [3]	Unified [4]
98	91	69	62	42	25	19	--------	33	12	--------	A-6(8)	CL
99	94	80	73	60	45	40	--------	47	27	--------	A-7-6(16)	CL
99	95	80	72	54	37	31	--------	47	31	--------	A-7-6(17)	CL
--------	100	99	90	66	38	27	--------	44	18	--------	A-7-6(12)	ML-CL
--------	100	99	94	76	48	39	--------	57	31	--------	A-7-6(19)	CH
--------	--------	100	93	67	39	31	--------	49	28	--------	A-7-6(17)	CL
--------	100	94	85	57	28	21	--------	35	14	--------	A-6(10)	CL
100	98	91	84	61	37	30	--------	41	21	--------	A-7-6(13)	CL
100	98	90	81	64	41	35	--------	45	27	--------	A-7-6(16)	CL
--------	--------	99	[5] 98	77	46	39	35	40	14	2. 52	A-6(10)	ML-CL
--------	--------	100	[5] 98	80	48	41	38	55	29	2. 62	A-7-6(19)	CH
--------	--------	100	[5] 99	81	43	35	33	46	21	2. 60	A-7-6(14)	ML-CL
--------	100	99	93	68	38	28	--------	41	18	--------	A-7-6(11)	CL
--------	100	99	96	79	51	43	--------	58	35	--------	A-7-6(20)	CH
--------	--------	100	95	66	39	31	--------	48	27	--------	A-7-6(16)	CL
--------	--------	98	89	55	23	15	--------	33	10	--------	A-4(8)	ML-CL
--------	100	99	93	66	39	31	--------	41	19	--------	A-7-6(12)	CL
--------	--------	100	95	73	46	38	--------	54	30	--------	A-7-6(19)	CH

and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[3] Based on method described in Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 8) The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation M 145-49.

[4] Based on the Unified Soil Classification System (*34*).

[5] Used No. 270 sieve and 1-minute hydrometer reading.

The Macksburg, Winterset, and other soils derived from loess in nearly level areas are fine textured. They are classified A–7 (CH) and have high group index numbers. The soil from the surface to a depth of about 2 feet is highly organic and is unsuitable for compaction to good density. Their subsoil is plastic silty clay loam or silty clay that expands readily and does not make a desirable upper subgrade. The Clinton, Ladoga, and Sharpsburg soils are among those loess-derived soils that have formed in more sloping areas. These soils are not so fine textured in the surface layer and have a less plastic subsoil than soils formed in nearly level areas. The subsoil material is classified A–7 (ML or CH) and has rather high group index numbers. Loessial soils tend to erode readily if runoff is concentrated. Sodding, paving, or check dams may be needed in gutters and ditches to prevent excessive erosion.

In soils derived from loess, the seasonal high water table is usually above the contact of the loess and glacial till, and seepage may occur in roadway cuts unless subdrains are installed. In the nearly level areas, a perched water table occurs above the B horizon in places. In places where the water table is high, the loess has a relatively low in-place density and has a high moisture content. The moisture may cause instability in embankments unless moisture-density control is exercised to permit compaction to high density.

On nearly level to moderately sloping uplands, the loess is underlain by strongly weathered glacial till that is heterogeneous, clayey, and of poor quality for construction work. The till is classified A–7–6(19–20). It is too expansive to be used for a highway subgrade and should not be used within 5 feet of a finished grade. This plastic clay crops out on slopes where the loess is thin, and the Clarinda, Keswick, and Lamoni soils have formed from it.

Below the clayey layer is heterogeneous glacial till that is classified primarily A–6 (CL). This till crops out on the lower parts of slopes and is the parent material of the Gara, Lindley, 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 are commonly interspersed throughout the till and in many places are water bearing. Frost heaving is possible if the road grade is only a few feet above such pockets and loess or loamy till. To prevent frost heaving, these pockets can be drained or the soil above them replaced by a backfill of coarse-textured material or good glacial till.

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 the soils derived from loess.

Limestone, sandstone, and shale are the kinds of bedrock underlying the glacial till. The Clanton and Gosport soils have formed in areas where loess or glacial till is underlain by shale. These soils are clayey and are not suited to use in grades. In places where embankments are constructed over sloping areas of shale, care is needed to assure that moisture is not left free to lubricate the surface of the shale and thus create the possibility of a slide. The shale can be stepped to form a level foundation. Also, if a cut is necessary through shale that has an overburden of glacial till or loess, the cut slope must be designed so that it is flat enough to eliminate a backslope slide when the shaly surface layer may be lubricated by moisture from natural infiltration areas. Nordness soils formed in material weathered from limestone. They are underlain at a depth of about 12 inches by limestone and have fragments on the surface and to this depth. Hixton soils formed in material weathered from sandstone and are underlain at a depth of about 2½ or 3 feet by slightly weathered sandstone. They are classified A–2 or A–4 (SM or SC) and are suitable for subgrade.

The soils on bottom lands formed in alluvium washed from the uplands. Of these soils, the Bremer, Wabash and Zook soils have a thick organic surface layer that may consolidate erratically under an embankment load. These clayey soils are classified A–7 (CH or CL–CH). They have a low in-place density and often have a high content of moisture. These clayey materials should not be placed in the upper part of embankments. The Judson, Kennebec, and Olmitz soils are other soils on bottom lands and on foot slopes that have a thick surface layer that is high in organic-matter content. If an embankment is to be more than 15 feet in height, all these soils should be carefully investigated to be sure they have sufficient strength to support it. Roadways through bottom lands should be constructed on a continuous embankment that extends above the level reached by floodwaters.

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 cutslopes, and as a source of borrow for road construction.

Formation and Classification of the Soils

This section discusses the factors that have affected the formation of the soils in Madison County. Also discussed is the classification of the soils. Detailed descriptions of profiles considered representative of the series are given in the section "Descriptions of the Soils." This section is useful for scientists, teachers, students, and others interested in the formation and classification of soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumlation; (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 the active factors in soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Usually a long time is required for the development of distinct horizons.

The factors of soil 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 soils of Madison County formed from six kinds of geologic material. Listed in the order of their influence on the soils of the county, the kinds of material are loess, glacial till, alluvium, shale, limestone, and sandstone. The relationships of some of the major soils to their parent materials are shown in figures 2, 5, 7, 9, and 10. In Madison County the various deposits and subsequent geologic erosion has resulted in the formation of a landscape characterized by broad, stable ridgetops occupied by soils formed in loess, gently sloping to steep side slopes occupied by soils that were derived from glacial till, shale, limestone, or sandstone, and numerous large and small stream valleys that have soils formed in alluvium. Except for the presence of shale, limestone, and sandstone bedrock, Madison County has a landscape similar to that of Adair County. In Adair County, which adjoins Madison County on the west, a detailed study has been made of the landscape evolution and soil formation by R. V. Ruhe, R. B. Daniels, and J. G. Cady (*21*). This study will be referred to in several places in succeeding sections.

Loess.—This is silty wind-deposited material that consists largely of silt particles and contains smaller amounts of clay and sand. It is the most extensive parent material in the county. It was deposited during the Wisconsin glacial period from about 24,500 to 14,000 years ago (*18*, *20*). The loess is believed to have been blown mainly from the flood plain of the Missouri River along the western side of Iowa (*7*). The thickness of loess and the differences between soils formed in loess are related to the distance from the source of the loess. The thickness of the loess in Madison County is about 12 to 18 feet on the nearly level, stable divides (*26*). The loess is thinner on the side slopes, and on most side slopes on the higher uplands all the loess has been removed by erosion and glacial till is exposed on the surface.

The loess in southwestern and southern Iowa gradually thins and becomes finer textured from west to east. The range in texture is not great in Madison County.

The Ladoga, Macksburg, Sharpsburg, and Winterset soils are the most extensive of the soils in Madison County that formed in loess. The Clearfield, Clinton, Nira, and Sperry soils are less extensive.

The loess and soils formed in loess in western and southwestern Iowa have been the subject of much study and investigation. Ruhe and others (*2*, *14*, *18*, *21*) have studied the relationship of the loess to the topography in western Iowa. Davidson and associates (*3*) studied the physical and engineering properties of loess in western Iowa and elsewhere. Ulrich (*29*, *30*) studied physical and chemical changes accompanying soil profile formation in soils formed in loess in southwest Iowa. Among the soils he studied were the Winterset soils. Other chemical and physical data on the Macksburg, Sharpsburg, and Winterset soils have been reported (*22*, *33*).

Glacial till.—Two glaciers have deposited material in Madison County, the Nebraskan and later the Kansan. The Nebraskan till is not identifiable on the landscape in Madison County, but was observed in a few deep cuts in the southwestern part. The Kansan till is exposed in all parts of the county, and in steep areas in the southern part, it forms an extensive part of the landscape. The unweathered till is firm, calcareous clay loam. It contains pebbles, boulders, and sand, as well as silt and clay. The till is a heterogeneous mixture and shows little evidence of sorting or stratification. The mineral composition of its components is also heterogeneous (*11*) and is similar to that of particles in unweathered loess.

Observations made during the survey indicate that the thickness of the glacial deposits in Madison County is 6 to 12 feet in areas where limestone and shale crop out but ranges to 100 feet or more in the southern part of the county. The thickness, hardness, or absence of the underlying sediments or rock has apparently had a direct affect on the thickness of the glacial till.

Soils had formed on the Kansan till plain during the Yarmouth and Sangamon interglacial period before the loess was deposited (*21*). In nearly level areas, the soils were strongly weathered and had a gray, plastic subsoil called gumbotil (*9*, *10*, *15*, *21*). This gumbotil is several feet thick and has very slow permeability. A widespread erosion surface has cut below the Yarmouth-Sangamon paleosol into Kansan till and older deposits. The surface is characterized generally by a stone line or subadjacent sediment and is surmounted by pedisediment (*15*, *16*, *17*, *18*, *19*). A paleosol formed in the pedisediment stone line and generally in the subadjacent till. This surface is referred to as Late Sangamon. The paleosols were less strongly weathered, more reddish in color, and not as thick as those in the nearly level areas.

The soils that formed in the Kansan till during Yarmouth and Sangamon ages were covered by loess. Geologic erosion has removed the loess from many slopes and has exposed these paleosols. In some places the paleosols have been beveled or truncated so that only the lower part of the strongly weathered paleosols remain. This erosion took place prior to loess deposition, or before about 25,000 years ago (*21*). In other places erosion has removed all of the paleosol and has exposed till that is only slightly weathered at the surface. This erosion took place mostly in post-glacial times.

The Clarinda soils formed in the Yarmouth-Sangamon paleosol of strongly weathered, gray clay. Lamoni soils have formed in the truncated Yarmouth-Sangamon paleosol. Their clay layer is not so thick as Clarinda soils. The Keswick soils formed where the less strongly weathered, reddish paleosol crops out. The Gara, Lindley, and Shelby soils formed in slightly weathered glacial till.

The Caleb and Mystic soils formed in pre-Sangamon erosional sediment of variable texture and glacial origin. These materials appear to have been angularly truncated in many places, commonly resulting in an irregular mixture of material of contrasting textures. Caleb and Mystic soils are on extended, stepped interfluves above the present drainage system. They owe their landscape configuration partly to valley fill, but their surface blends with the present erosional uplands. These soils are distinctly higher in elevation than the modern flood plains but are lower than the Gara, Lindley, and Shelby soils. The Mystic soils are on the most stable part of interfluves and have inherited many of their characteristics from the Late Sangamon paleosol. Caleb soils are downslope on that part of the interfluves that has been truncated in Recent (Wisconsin) time.

Alluvium.—This consists of sediment that has been deposited along major and minor streams and drainageways, as well as on benches. The texture of the alluvium varies widely because of differences in material from which the alluvium came and the manner in which it was deposited. In Madison County the main sources of alluvium have been loess, glacial till, and layers of exposed shale. In places along the North and Middle Rivers, fragmented and broken limestone has been washed down from steep side slopes. These fragments form a flaggy substratum for silty and loamy alluvium deposited later in narrow stream bottoms and on foot slopes.

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. Judson soils, for example, generally are at the base of slopes below soils formed in loess. Judson soils are silty and are similar in texture to the soils upslope. The Olmitz soils also have formed in local alluvium, but they are downslope from till-derived soils. They contain more sand than Judson soils because the alluvium in which they formed came from sandier soils. The Martinsburg and Ely soils are other soils that formed in local alluvium.

As the rivers and streams overflow their channels, the coarse textured or sandy material is deposited first, adjacent to the stream. As the water spreads outward toward the uplands, it moves more slowly and silt and very fine sand are deposited. During high floods the water spreads slowly toward the outer border of the flood plains and carries particles of very fine silt and clay. As the floodwater recedes, these particles settle and are mixed with the fine particles washed down as local alluvium.

This pattern is demonstrated in many places on the wider stream bottoms of the North, Middle, and Grand Rivers. Away from areas of Alluvial land nearest the streams, there are areas of Spillville, Nodaway, and Kennebec soils, in that order. The Nodaway soils are mainly coarse silt but contain some fine sand and clay. The Kennebec soils are more silty and contain less sand and more clay. Farther away from the main channel are the Zook and Wabash soils. These are the finest textured, most poorly drained soils, and they are somewhat lower in elevation than the other soils.

Along the main streams in the north-central and central parts of the county, there are benches or second bottoms. On these have formed alluvial soils that have a wide range of texture, that are much less subject to flooding, and that have more profile development. These soils, in order of increasingly fine texture and poor drainage, are the Wiota, Nevin, Vesser, and Bremer soils.

In some areas, streams are still cutting through limestone and shale, and flood plains are narrower. In these areas, older flood plains are now separated by escarpments from the lower, narrow first bottoms. It is not uncommon for the fine-textured Wabash and Zook soils near uplands to be separated from the coarser textured Nodaway, Spillville, and Kennebec soils by loess-covered benches and escarpments.

Limestone, sandstone, and shale.—The oldest parent material in the county is a series of beds deposited during a sedimentary cycle in the Pennsylvanian period (*28*). These beds consist of limestone, shale of different colors and textures, sandstone, and layers of organic material, such as coal. There is a wide range in thickness of these layers or beds. In Madison County, coal veins are only a few inches thick and are insignificant.

One site south of Patterson, described to a depth of 164 feet by Tilton and Bain (*6*, *28*), showed 14 layers, or beds, ranging from 5 inches to 32 feet in thickness. Observations made in cuts during the survey indicated four to eight layers were commonly exposed. Outcrops of these materials are mainly on slopes along streams in the Clinton-Lindley-Steep rock land-Clanton association.

The limestone beds range from a few inches to many feet in thickness and are fossiliferous in nature. Some are underlain by rocklike, cemented, highly calcareous, bluish-gray shale. Colors of the shale range from nearly black to red, but red, brown, and grayish colors are dominant. Thin beds of sandstone and coal are between the layers of shale in places. The range in thickness of the limestone, shale, and sandstone layers is so great, however, that in some places a single bed of one of them dominates the entire side slope.

A study by Slusher [5] indicates a wide range of texture, reaction, and other characteristics in soil profiles formed in shales in southern Iowa.

The Nordness soils formed on the surface of fragmented and somewhat weathered limestone. Limestone ledges, outcrops, and limestone fragments mixed with till, loess, and shale are dominant in areas of Steep rock land and Sloping stony land.

The Gosport soils formed in brownish-colored shale, and the somewhat darker Clanton soils in red shale (fig. 22). These soils are common in the county. A thick bed of red shale is dominant in an area east of Peru. The Hixton soils formed in material derived from sandstone. These soils are confined to an area west of St. Charles where the sandstone strata are relatively thick.

Eolian (windblown) sand consists largely of fine quartz sand that, in Madison County, is mixed with some silt. It has been blown from stream bottoms and has been deposited on nearby ridgetops from side slopes. Areas of this sand are small and minor in extent, and so they are shown on the soil map by a spot symbol for sand.

Climate

Madison County soils, according to recent evidence, have been developing under the influence of a variable climate. Walker (*35*) in recent studies concluded that in the post-Cary glaciation, which occurred from about 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominantly conifers. During the period from 10,500 to 8,000 years ago, however, there was a

[5] SLUSHER, DAVID F. MORPHOLOGY OF SOME SHALE DERIVED SOILS IN SOUTHERN IOWA. Unpublished M.S. thesis, Iowa State University Library, Ames, Iowa.

Figure 22.—A railroad right-of-way cut through layers of shale.

warming trend and a change in vegetation from conifers to mixed forest in which hardwood species were prominent. Beginning about 8,000 years ago, the climate became still warmer and also drier. Herbaceous prairie plants became dominant and remained so to the present time. McComb and Loomis (*12*) concluded from studies made of the transition from forest to prairie in central Iowa that a late change in postglacial climate from relatively dry prairie to a climate marked by a moderate amount of moisture has taken place. Walker's evidence indicates that this change may have begun about 3,000 years ago. The present climate is midcontinental subhumid.

Nearly uniform climate prevails throughout the county. In or near the developing soil, however, the influence of the general climate is modified by local conditions. For example, south-facing slopes have a microclimate that is warmer and less humid than the average climate of nearby areas. Low-lying, poorly drained bottoms are wetter and colder than most areas around them.

The general climate has had an important overall influence on the characteristics of the soils, but has not caused major differences among them. The local climatic differences influence the characteristics of the soils within the same climatic region.

Weathering of the parent material by water and air is activated by changes in temperature. As a result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its effect on the amount of leaching in soils and on the kinds of plants that grow. Some variations in plant and animal life are caused by variations in temperature or by the action of other climatic forces on the soil material. To that extent, climate influences changes in soils that are brought about by differences in plant and animal populations.

Plant and animal life

Many kinds of living organisms are important in soil development. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. Differences in the kind of vegetation commonly cause the most marked differences between soils (*13*).

The preceding subsection discusses the fact that the dominant kinds of plant life have changed with time. The soils of Madison County appear to have been influenced in recent times by two main types of vegetation, prairie grasses and trees. The main prairie grasses were big bluestem and little bluestem. The main trees were deciduous, mostly oak, hickory, ash, and elm.

In Madison County, tall prairie grasses were the dominant plants at the time of settlement on the broad, nearly level to gently rolling uplands. Trees were present, however, near most major streams and their major tributaries. Trees occupied about 70,000 acres at the time of settlement.

Because grasses have many roots and tops that have decayed on or in the soil, soils formed under prairie vegetation typically have a thicker, darker-colored surface layer than do soils that formed under trees. Under trees the organic matter, derived principally from leaves, was deposited mainly on the surface layer of the soil. Soils that formed under trees generally are more acid and have had more downward movement of bases and clay minerals in their profiles.

The Sharpsburg and Macksburg soils are typical of soils that formed in loess under prairie vegetation, as are the Shelby soils that formed in glacial till.

The Clinton and Lindley soils are among those in Madison County that formed under forest vegetation. Clinton soils formed in loess, and Lindley soils in glacial till. These soils have a thin, light-colored A1 horizon; a prominent, gray A2 horizon that is very distinct when dry; and B horizons that have stronger structure and show more evidence of the accumulation of silicate clay than prairie soils.

Such soils as the Ladoga and Gara, however, have properties that are intermediate between those of soils formed entirely under trees and those of soils formed under grass. It is believed that the Ladoga and Gara soils formed under prairie grasses but later were covered by trees. Their morphology reflects the influence of both trees and grass.

Relief

Relief, or topography, refers to the lay of the land. It ranges from nearly level to very steep in Madison County. Relief is an important factor in soil formation because of its effect on drainage, runoff, height of the water table, and erosion.

A difference in relief is the main reason for the differing soil properties of some of the soils in the county. Even though soils have formed in the same parent material, the influence of relief is seen in the color, thickness of the solum, and horizonation of the soils. This influence can be seen in a sequence of soils in Madison County. The Sperry, Winterset, and Macksburg soils all formed in loess under similar vegetation but at different positions on the landscape. The Sperry soils are very poorly drained and are in low places where water accumulates. The Sharpsburg soils are moderately well drained and have slopes that cause some of the water from rain and melting snow to run off. Water that does not run off either percolates to lower depths or evaporates. The water that percolates through the soil removes clay from the A horizon, and much of this clay accumulates in the B horizon. The Sperry soils in depressions have more clay accumulated in the B horizon than the sloping Sharpsburg soils because more water percolates through the profile of Sperry soils. The content of clay in the B horizon is generally greater in gently sloping or level areas than in steep areas. This content is progressively higher in the Sharpsburg, the Macksburg, the Winterset, and the Sperry soils. The clay content of Winterset and Sharpsburg soils has been reported in detail by Ulrich (*29*, *30*) and Hutton (*7*, *8*), respectively.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. On the other hand, the subsoil of soils that have restricted drainage generally is grayish in color and mottled. The Sperry soils are in depressions and have a grayish B horizon. Sharpsburg soils are sloping and have a brownish-colored B horizon.

On the Shelby and similar soils that have a wide range of slopes and landscapes, the depth to carbonates is increasingly less as the slope increases and the slopes are more convex.

Slope affects runoff, and this in turn affects the amount of moisture available for plants. The lack of moisture has, in some places, restricted the growth of plants on some of the steeper Shelby and Sharpsburg soils. This helps to account for the differences in the thickness and organic-matter content of the surface layer in these soils and in less sloping soils of the Shelby and Sharpsburg and other series.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in the parent material. Similar kinds of soils form in widely different kinds of parent material if other factors continue to operate over long periods of time. But soil development is generally interrupted by geologic events that expose new parent material. In Madison County new parent material has been added to the uplands at least three times (*26*).

The bedrock has been covered by glacial drift from two different glaciers. Then, the present surface material, consisting of loess, was deposited. As a result, soils have been buried and further development of those soils has stopped.

According to studies by Ruhe and others (*21*), the Clarinda, Lamoni, and Keswick soils have horizons in their subsoil that are among the most weathered in the county. These soils formed in Kansan till, which began to weather in Yarmouth and Sangamon times. Then, the soils were covered by loess. More recently, when the loess was removed by erosion, the upper material in the ancient subsoil was exposed to weathering again. The Clarinda, Lamoni, Keswick, Adair, and Mystic soils are also referred to as paleosols. The glacial till is underlain by even older beds of limestone, shale, and sandstone. These also have been exposed on the landscape. Here, soils such as the Gosport, Clanton, Hixton, and Nordness soils have formed. These soils vary greatly in weathering, some of which may be of paleosol origin.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating soils formed partly in Wisconsin age (*14*, *19*). Loess deposition began about 25,000 years ago and continued to about 14,000 years ago (*5*, *18*). Based on these dates, the surface of nearly level, loess-mantled divides in Iowa is about 14,000 years old. In Madison County these stable areas include nearly level and most of the gently sloping divides. They are mainly occupied by such soils as Winterset, Macksburg, and Sharpsburg soils. In much of Iowa, including Madison County, geologic erosion has beveled and, in places, removed material on side slopes and deposited new sediments downslope (*21*). The surface of nearly level upland divides is older than the slopes that bevel and ascend to the divides. Thus, the side slopes are less than 14,000 years old. In Madison County, the Gara, Lindley, and Shelby soils are among those soils that are on side slopes.

The sediment stripped from side slopes accumulated to form local alluvium. The age of side slopes is determined by dating the alluvial fill at the base of slopes. Studies by Ruhe, Daniels, and Cady (*21*) in neighboring Adair County indicate that the base of the alluvial fill is about 6,800 years old. Daniels and Jordon (*2*) found that alluvium in some stream valleys in western Iowa is less than 1,800 years old. Because the sediments from the side slopes accumulated to form the alluvium, the side slope surface in these areas is as young or younger than these dates. Some of the soils that have formed in similar areas of alluvium in Madison County are Ely, Judson, Kennebec, Olmitz, and Zook soils. Nodaway soils formed in alluvium, some of which was deposited since settlement by man.

Man's influence on the soil

Important changes have taken place in the soils since Madison County was settled. Breaking the prairie sod and clearing the timber removed and changed the protective cover.

The most apparent changes are those caused by water erosion. As the land was brought under cultivation, the surface runoff increased and the rate at which water moved into the soil decreased. This resulted in accelerated erosion that has removed part or all of the original surface layer from much of the sloping soils under cultivation. In some places, shallow to deep gullies have formed.

Erosion has not only changed the thickness of the surface layer, but its structure and consistence as well. In severely eroded areas, the plow layer commonly consists partly of the upper part of the subsoil, which is less friable and finer textured than the surface layer.

Erosion and cultivation also affect the soil by reducing the organic-matter content and lowering fertility. Even in areas not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and changes the structure. The granular structure, so apparent in natural grassland, breaks down under intensive cropping.

On the other hand, man has done much to increase productivity, to decrease soil loss, and to reclaim areas not suitable for crops or pasture. For example, terraces, erosion control structures, and other management practices have slowed or, in some places, controlled runoff and erosion. The establishment of diversions at the base of slopes and of drainage ditches and other practices has aided in the prevention of flooding and deposition, and this has made large areas of bottom land suitable for cultivation.

Through the use of commercial fertilizers and lime, the deficiencies in plant nutrients are corrected, so that many soils are more productive now than they were in their natural state.

Erosion is a main cause of the reduction of organic matter in soils. Figures indicate, however, that as much as one-third of the organic matter can be lost from causes other than erosion (*27*). Management practices have shown that it is not economically feasible to maintain as high a reserve of organic matter as was originally present under native grasses. It is necessary, however, to maintain a safe and economical level for crops. In soils lowest in organic-matter content, this is done by control of the major cause of loess erosion by water.

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Processes of Horizon Differentiation

Horizon differentiation is considered to be caused by four basic kinds of change. These are additions, removals, transfers, and transformations in the soil system (*24*). Each of these four kinds of change affects many substances that compose soils. For example, there may be additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals.

In general, these processes tend to promote horizon differentiation, but some tend to offset or retard it. These processes and the changes brought about proceed simultaneously in soils, and the ultimate nature of the profile is governed by the balance of these changes within the profile.

An accumulation of organic matter is an early step in the process of horizon differentiation in most soils. Soils in Madison County range from high to very low in the amount of organic matter that has accumulated in their A1 horizon. Clinton and Lindley soils, for example, have a thin A1 horizon that is low in organic-matter content. Winterset and Colo soils are among those that have a thick A1 horizon in which the content of organic matter is high. Some soils that were formerly quite high in organic-matter content are now low because of erosion. The accumulation of organic matter has been an important process in the differentiation of soil horizons in Madison County.

The process through which substances are removed from parts of the soil profile is important in the differentiation of soil horizons in Madison County. The movement of calcium carbonates and bases downward in soils is an example. All the soils in the county, except Nordness soils, have been leached free of calcium carbonates in the upper part of their profile, and some soils have been so strongly leached that they are strongly acid or very strongly acid in their subsoil.

A number of kinds of transfers of substances from one horizon to another are evident in the soils of this county.

Phosphorus is removed from the subsoil by plant roots and transferred to parts of the plant growing above the ground. Then it is added to the surface layer in the plant residue. These processes affect the forms and the distribution of phosphorus in the profile.

The translocation of silicate clay minerals is an important process in horizon differentiation. The clay minerals are carried downward in suspension in percolating water from the A horizon. They accumulate in the B horizon in pores and root channels and as clay films on ped faces. In Madison County, this process has had an influence on the profiles of many of the soils. In other soils, the clay contents of the A and B horizons are not markedly different and other evidence of clay movements is minimal.

Another kind of transfer that is minimal in most soils, but occurs to some extent in very clayey soils, is that brought about by shrinking and swelling. This causes cracks to form and the incorporation of some materials from the surface layer into lower parts of the profile. Wabash and Clarinda soils are examples of soils with potential for this kind of physical transfer.

Transformation are physical and chemical. For example, soil particles are weathered to smaller sizes. The reduction of iron is another example of a transformation. This process is called gleying and involves the saturation of the soil with water for long periods in the presence of organic matter. It is characterized by the presence of ferrous iron and gray colors. Gleying is associated with poorly drained soils such as the Winterset soils. Reductive extractable iron, or free iron, is normally lower in somewhat poorly drained soils such as the Macksburg soils (*33*).

Still another kind of transformation is the weathering of the primary apatite mineral present in soil parent materials to secondary phosphorus compounds.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their 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.

The system currently used for classifying soils was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*25*, *32*). 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 are given for each soil series in table 6. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histisols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histisols, occur in many different climates.

Table 6 shows the four orders in Madison County: Mollisols, Entisols, Inceptisols, and Alfisols. Entisols are recent soils that do not have genetic horizons or have only the beginnings of such horizons. Mollisols have a thick surface layer that is darkened by organic matter. Alfisols are soils that have a clay-enriched B horizon that is high in base saturation. Inceptisols are soils that have diagnostic horizons that are thought to form fairly quickly. They are most commonly on young, but not recent, land surfaces.

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 the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of wetness or soil differences resulting from climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Udolls (*Ud*, meaning humid, and *oll* from mollisol).

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 names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Hapludalf (*Hapl*, meaning simple, *ud* for humid, and *alf* for alfisol).

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Hapludalf.

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. The family name consists of a series of adjectives preceding the subgroup name. An example is the fine-loamy, mixed, mesic family of Typic Hapludalfs.

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 county. 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. They are given the name of a geographic location near the place where that series was first observed and mapped. An example is the Sharpsburg series.

TABLE 6.—*Classification of the soil series*

Series	Family	Subgroup	Order
Arbor	Fine-loamy, mixed, mesic	Typic Argiudolls (Hapludolls)	Mollisols.
Bremer	Fine, montmorillonitic, mesic	Typic Argiaquolls (Cumulic Haplaquolls).	Mollisols.
Caleb	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Clanton	Fine, illitic, mesic	Mollic Hapludalfs (Paleudalfs)	Alfisols.
Clarinda	Fine, montmorillonitic, mesic, sloping	Typic Argiaquolls	Mollisols.
Clearfield	Fine-silty, mixed, mesic, sloping	Typic Argiaquolls (Haplaquolls)	Mollisols.
Clinton	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Dunbarton	Clayey, montmorillonitic, mesic	Lithic Hapludalfs	Alfisols.
Ely	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Gara	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Givin	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Gosport	Fine, ililitic, mesic	Typic Dystrochrepts	Inceptisols.
Hixton [1]	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludalfs	Alfisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Keswick	Fine, montmorillonitic, mesic	Aquic Hapludalfs	Alfisols.
Ladoga	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Lamoni [2]	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Lindley	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Macksburg	Fine, montmorillonitic	Aquic Argiudolls	Mollisols.
Martinsburg	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Mystic	Fine, montmorillonitic, mesic	Aquollic Hapludalfs	Alfisols.
Nevin	Fine-silty, mixed, mesic	Aquic Argiudolls (Hapludolls)	Mollisols.
Nira	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Nodaway	Fine-silty, mixed, nonacid, mesic	Typic Udifluvents	Entisols.
Nordness [3]	Loamy, mixed, mesic	Lithic Hapludalfs	Alfisols.
Olmitz	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Sharpsburg	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Shelby [4]	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sperry	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Spillville [5]	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Vesser	Fine-silty, mixed, mesic	Argiaquic Argialbolls	Mollisols.
Wabash	Fine, montmorillonitic, noncalcareous, mesic	Vertic Haplaquolls	Mollisols.
Winterset	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Wiota	Fine-silty, mixed, mesic	Typic Argiudolls (Cumulic Hapludolls)	Mollisols.
Zook	Fine, montmorillonitic, noncalcareuos, mesic	Cumulic Haplaquolls	Mollisols.

[1] These soils are taxadjuncts to the Hixton series and are coarser textured than is typical for the series.
[2] Lamoni clay loam, 9 to 14 percent slopes, severely eroded, is a taxadjunct to the Lamoni series and has a surface horizon either too thin or too light in color to qualify for mollic epipedon.
[3] These soils are taxadjuncts to the Nordness series, and the subsoil has grayer hues than is typical for the series.
[4] Shelby soils, 14 to 18 percent slopes, severely eroded, is a taxadjunct to the Shelby series and has a surface horizon either too thin or too light colored to qualify for mollic epipedon.
[5] Spillville loam, flaggy substratum, is a taxadjunct to the Spillville series and has a flaggy loam substratum at a depth of less than 40 inches.

General Nature of the County

This section is primarily for readers not familiar with Madison County. It tells about the history, farming, and transportation of the county. Then it gives a short discussion of topography, drainage, and climate.

History

Madison County was established in 1846 and named after the fourth president of the United States. The site of the county seat, in the exact center of the new county, was selected the same year, before many settlers had arrived.

The first white settlers came in 1845 and early in 1846. The only inhabitants at that time were Indians. By 1849 there were 700 settlers.

Many sawmills and gristmills were established in the county. Early settlers included good carpenters, and the limestone ledges attracted skilled stonecutters and masons. Consequently, many stone houses, schoolhouses, and other buildings were built from 1855 until after the Civil War. Many of these buildings are still in excellent condition. The present courthouse was built in 1875 of stone that was quarried, shaped, and cut in the county. The woodwork is of native black walnut and oak. This quarrying of rock paved the way for early use of limestone for concrete, road rock, and agricultural lime in central Iowa (fig. 23).

Settlers from New England influenced bridge construction. All early bridges were covered. Seven covered bridges, some nearly 100 years old, are now maintained for both practical and scenic value.

The original Delicious variety of apple was discovered in Madison County. The first tree was killed by an early, hard freeze in 1940, but the stump is still preserved near Peru, Iowa.

Figure 23.—**A limestone quarry near Winterset.**

Farming [6]

The trend in the county in recent years has been toward a gradual decrease in the number of farms and in the rural population. This has been accompanied by a corresponding increase in the size of farms and in the percentage of owner-operated farms. The following paragraphs give information on farming based on the Iowa Annual Farm Census for 1965.

Total acreage of the county is 361,600, and 355,730 acres of this was in farms in 1965. In 1965 there were 1,473 farms averaging 242 acres per farm. Those living on farms totaled 5,254. Owner-operated farms made up 65.8 percent of the total, and tenant-operated farms made up 34.2 percent. Most tenants operated on a stock-share or crop-share basis.

According to 1965 figures, 189,179 acres was in crops, 144,024 acres was in pasture, and 22,527 acres was in roads, farmsteads, and unpastured woodland. The acreage in pasture includes large areas of woodland that provide little grazing. Many areas have been and are being cleared. About 42,000 acres of the county are still too heavily wooded to provide much pasture.

About 80 percent of the grain produced is fed to livestock, and 20 percent is sold for cash. Soybeans are mostly sold for cash. Corn, soybeans, and oats show a gradual increase in acreage, yield, and quality. The acreage in minor crops fluctuates a great deal and shows a general decrease, but these crops are important to some individual farms.

The amount of land in the different crops in 1965 included 73,282 acres of corn, 15,048 acres of oats, 40,491 acres of soybeans, 36,392 acres of hay, and 144,024 acres of pasture. In addition, there were 23,658 acres of crops that were not harvested or pastured.

Livestock is a major source of income on most farms in Madison County. The amount of livestock on hand or produced in Madison County in 1965 is as follows: dairy cows on hand, 2,023; beef cows on hand, 26,023; calves born, 25,797; lambs born, 6,980; cattle marketed, 14,991; sheep marketed, 4,484; and sows farrowed in fall of 1965, 9,740, and in spring of 1966, 12,494. Poultry on hand or sold in 1965 included 6,240 broilers sold, 55,967 laying hens kept, and 3,736 turkeys sold.

Most beef cattle, hogs, and lambs are trucked to markets at Des Moines, Omaha, and other places. Grain and soybeans are handled mainly by local elevators, but some are trucked to Des Moines or Creston. Most milk is picked up or delivered regularly to cooperative creameries and dairies in the Des Moines or Creston area.

Poultry products are usually marketed by contract with larger producers near larger cities. Some are handled by local produce dealers. Wool is mostly sold to local buyers.

[6] HENRY I. STUCHEL, JR., extension director for Madison County, helped to prepare this subsection.

Transportation

Two major highways are centrally located in the county. State Route 92 traverses the county from east to west and joins Interstate Highway No. 35 one-half mile east of the county line in Warren County. U.S. Highway No. 169 traverses the county from north to south and joins the east-west Interstate Highway No. 80 one mile north of the county line at De Soto in Dallas County. These two major highways intersect at the centrally located county seat of Winterset. Hard-surfaced State highways or county roads connect these highways to all of the smaller communities in the county. All farms are on farm-to-market roads of crushed limestone. Major county roads are well distributed over the county.

The Chicago, Rock Island and Pacific Railroad dips into the northern part of the county through Earlham. A branch line extends to Winterset from Earlham. The Chicago and North Western Railroad, connecting Minneapolis and Kansas City, goes through the southeastern part.

Bus transportation is available through Winterset in all directions. The major airport in Des Moines is readily accessible to all parts of the county. Motor freight lines serve every trading center in the county.

Topography

The original topography of the county was that of a plain on uplands that sloped to the northeast at the rate of about 10 feet per mile. This has been greatly modified by sheet and gully erosion and the trenching of streams. The trenching and landscape-shaping actions of the larger streams and their tributaries were greatly influenced by the geologic materials exposed below the original loess-mantled plain. The remnants of this plain now occupy a series of stable, loess-mantled divides throughout the county. These divides are less stable and more narrow in the eastern part of the county.

The highest elevation in the county is on the Missouri-Mississippi divide in the southwestern part of the county. This divide is relatively narrow and runs in a southeasterly direction from the county line in Webster Township through the town of Macksburg and the southwestern part of Monroe Township. The lowest elevation is near the stream channel of Middle River near the town of of Bevington. The drop in elevation is about 450 feet.

The larger streams have formed valleys 100 to 250 feet below the upland plain. The south slopes of these valleys are typically abrupt and steep. On the north side, the valley slopes are less steep and are longer. In areas of the county where limestone crops out, the stream valleys tend to be V-shaped and to have steep slopes. The bottom lands are narrow, and the tributaries of the main streams are short.

In the east-central part of the county, the topography is characterized by narrow, unstable divides; steep valley slopes; broad, nearly level bottom lands; and benches as much as a mile wide or more. Here, tributary streams have cut only a short distance back into the uplands through the thin layers of glacial till and the shale beds that underlie the loess mantle.

Most of the rest of the county, except along major streams, has topography more typical of most of southern Iowa. Approximately a quarter of the county is nearly level, and the rest is mostly rolling. The side slopes are more rounded and uniform but range from gently sloping to steep. Here, the tributary streams are cutting into thick deposits of glacial till, are longer, and extend further into the uplands.

Drainage

The natural drainage of Madison County is provided by four major streams and their tributaries. These are North River and Middle River in the central and northern parts of the county, Grand River in the extreme southwestern part, and South River in the extreme southeastern part. Runoff water south and west of the Missouri-Mississippi divide in the southwestern part of the county flows into the Grand River and eventually into the Missouri River. The drainage in the rest of the county is eastward to the Mississippi River through its tributary, the Des Moines River.

Most of the natural drainage in the county north and east of the Missouri-Mississippi divide is provided by the Middle River in the central part of the county, which flows eastward, and the North River, which flows southeastward from the northwestern part of the county. Small areas in the north-central and extreme northeastern parts drain into the Raccoon River to the north. South River drains only a small part of the county southeast of Truro. It flows northeast.

Climate [7]

The inland location of Madison County gives 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.

Precipitation averages about 32 inches per year, about 10 percent of which falls as snow. Average snowfall is about 30 inches annually (table 7). Measurable precipitation is recorded about 104 days per year. Of these 104 days, 56 have more than one-tenth inch and 19 have one-half inch or more. Fifteen of the 19 days that have one-half inch or more of precipitation are in the warm half of the year, and these reach a peak during May and June. During 12 of the 19 days with one-half inch or more of rain, precipitation ranges upward to 1 inch. During 5 of the days, the amount is from 1 to 2 inches, and 1 day per year averages 2 inches or more of rainfall. The heaviest rainfalls during most years are in spring, before crop emergence or before the emerged crops have established adequate root systems and ground cover to prevent erosion. Floods, though rare, usually occur late in March or in June.

Dry spells are most likely to occur in July and August. Well-developed corn requires about 1 inch of available moisture per week during the summer. The probability of receiving 1 inch of rainfall ranges from about 45 percent per week early in June to about 25 percent late in July.

[7] By PAUL J. WAITE, climatologist for Iowa, National Weather Service, U.S. Department of Commerce.

TABLE 7.—*Temperature and precipitation*

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average highest maximum	Average lowest minimum	Average total	1 year in 10 will have—		Days with snow cover of 1.0 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	32	13	53	−11	1.1	0.4	2.0	16	5
February	37	17	56	−7	1.1	0.2	2.2	11	4
March	46	26	72	4	1.9	0.8	4.3	7	7
April	63	39	83	22	3.0	0.9	5.7	(1)	(2)
May	74	51	89	33	4.1	1.8	7.4	0	0
June	82	60	95	45	4.8	1.5	8.0	0	0
July	88	65	99	52	3.6	0.9	8.2	0	0
August	86	63	97	48	3.9	1.5	8.6	0	0
September	79	54	93	35	3.6	1.6	6.8	0	0
October	68	43	85	24	2.3	0.1	4.6	0	0
November	49	28	72	8	1.6	0.2	5.0	2	2
December	37	19	57	−4	1.1	0.2	2.0	8	4
Year	62	40	100	−15	32.1	22.6	42.5	44	5

[1] Less than one-half day.

[2] Less than one-half inch.

Consequently, a moderate supply of soil moisture is needed almost every spring to assure good crop growth.

Minimum temperatures on calm, clear nights may vary 10 degrees or more. The rural valleys and lowlands often are several degrees colder on clear, calm nights than are urban and upland areas. Maximum temperatures normally are about the same throughout the county. On about 33 days per year, temperatures reach 90° F. or higher. This is usually too warm for optimum crop growth and development, because the high evapotranspiration rate causes plant stress. Freezes occur an average of 153 days per year. The average date of the last freeze in spring is May 5, and the average date of the first freeze in autumn is October 3. At the weather station located 3 miles northwest of Winterset, the growing season averages 151 days. On uplands the season is usually a few days longer.

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Glossary

Acidity. See Reaction.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Alluvium, local. Soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bench position. A high, shelflike position.

Bottom land. The normal flood plain of a stream and the old alluvial plain that is seldom flooded. See Bottoms, first.

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 that contains enough calcium carbonate (often with magnesium carbonate) to efferversce (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.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Contour tillage. Cultivation that follows the contour of the land in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

Drainage, soil. Refers to the condition of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. The terms used to express the various degrees of natural drainage are: excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial drift (geology). Rock material transported by glacial ice and then deposited; includes the assorted and unassorted materials deposited by streams flowing from glaciers.

Glacial outwash (geology). Cross-bedded gravel, sand, and silt deposited by melt-water as it flowed from glacial ice. Referred to in this survey as "outwash areas" or "outwashes."

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major soil horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock generally underlies a C horizon but may be immediately beneath an A or B horizon.

Interfluve. The land between two adjacent streams flowing in the same general direction.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

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.

Paleosol. An antiquated soil that was formed during the geologic past and was buried and preserved by more recent sedimentation. This kind of buried soil is commonly reexposed on the modern surface by subsequent erosion. It then occurs within the continuum of soils on the modern surface and is called an exhumed paleosol.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Percolation. The downward movement of water through soil.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

pH value. A numerical means for designating relatively weak acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeters) to the lower limit of very fine sand (0.05 millimeters). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (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 solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

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 (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Terrace. 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 formed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions of fine particles, are *sand, silty clay loam, sandy 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.

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

☆ U.S. Government Printing Office 1975: 575-807/91

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