SOIL SURVEY OF

Howard County, Missouri

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Missouri Agricultural Experiment Station

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

Major fieldwork for this soil survey was completed in the period 1953–58. Soil names and descriptions were approved in 1975. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1975. This survey was made cooperatively by the Soil Conservation Service and the Missouri Agricultural Experiment Station. It is part of the technical assistance furnished to the Soil and Water Conservation District of Howard County.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All of the soils of Howard 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 and gives the capability classification of each. It also shows the page where each soil is described and shows the capability unit and tree and shrub 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 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 groupings, and the woodland management and productivity.

Foresters and others can refer to the section "Woodland Management and Productivity," where management concerns and potential productivity are given for soils of the county.

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

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

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

Newcomers in Howard 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 about the county given in the section "Environmental Factors Affecting Soil Use."

Contents

	Page
Index to soil mapping units	ii
Summary of tables	iii
How this survey was made	1
General soil map	2
1. Grundy-Greenton-Sharpsburg association	3
2. Winfield-Lindley-Mandeville association	4
3. Menfro-Lindley-Norris association	5
4. Lindley-Hatton-Mandeville association	5
5. Knox-Marshall association	6
6. Gara-Weller-Ladoga association	7
7. Leta-Haynie-Hodge association	7
8. Nodaway-Fatima-Bremer association	8
Armstrong series	9
Bremer series	9
Carlow series	11
Chariton series	11
Edina series	13
Fatima series	13
Freeburg series	14
Gara series	15
Greenton series	16
Grundy series	18
Gullied land	19
Hatton series	21
Haynie series	22
Hodge series	23
Descriptions of the soils	24
Keswick series	24
Knox series	25
Ladoga series	27
Leta series	28
Lindley series	29
Mandeville series	31
Marion series	33
Marshall series	33
McGirk series	34
Menfro series	35
Mexico series	37
Moniteau series	38
Napier series	39
Nodaway series	40
Norris series	41
Pershing series	42
Riverwash	43
Sarpy series	44
Sharpsburg series	44
Weller series	45
Winfield series	47
Use and management of the soils	49
Cultivated crops and pasture	49
Capability grouping	50
Predicted yields	51
Woodland management and productivity	53
Use of soils for trees and shrubs for environmental improvement	57
Use of the soils for wildlife habitat	57
Use of the soils for recreational development	63
Engineering uses of the soils	66
Engineering soil classification systems	67
Soil properties significant to engineering	70
Engineering interpretations of soils	71
Formation and classification of the soils	77
Factors of soil formation	77
Parent material	77
Climate	86
Plant and animal life	86
Relief	87
Time	87
Classification of soils	87
Environmental factors affecting soil use	89
Settlement and population	89
Relief and drainage	90
Communication, transportation, and industry	90
Educational, cultural, and recreational facilities	90
Climate	90
References	91
Glossary	92
Guide to mapping units Following	94

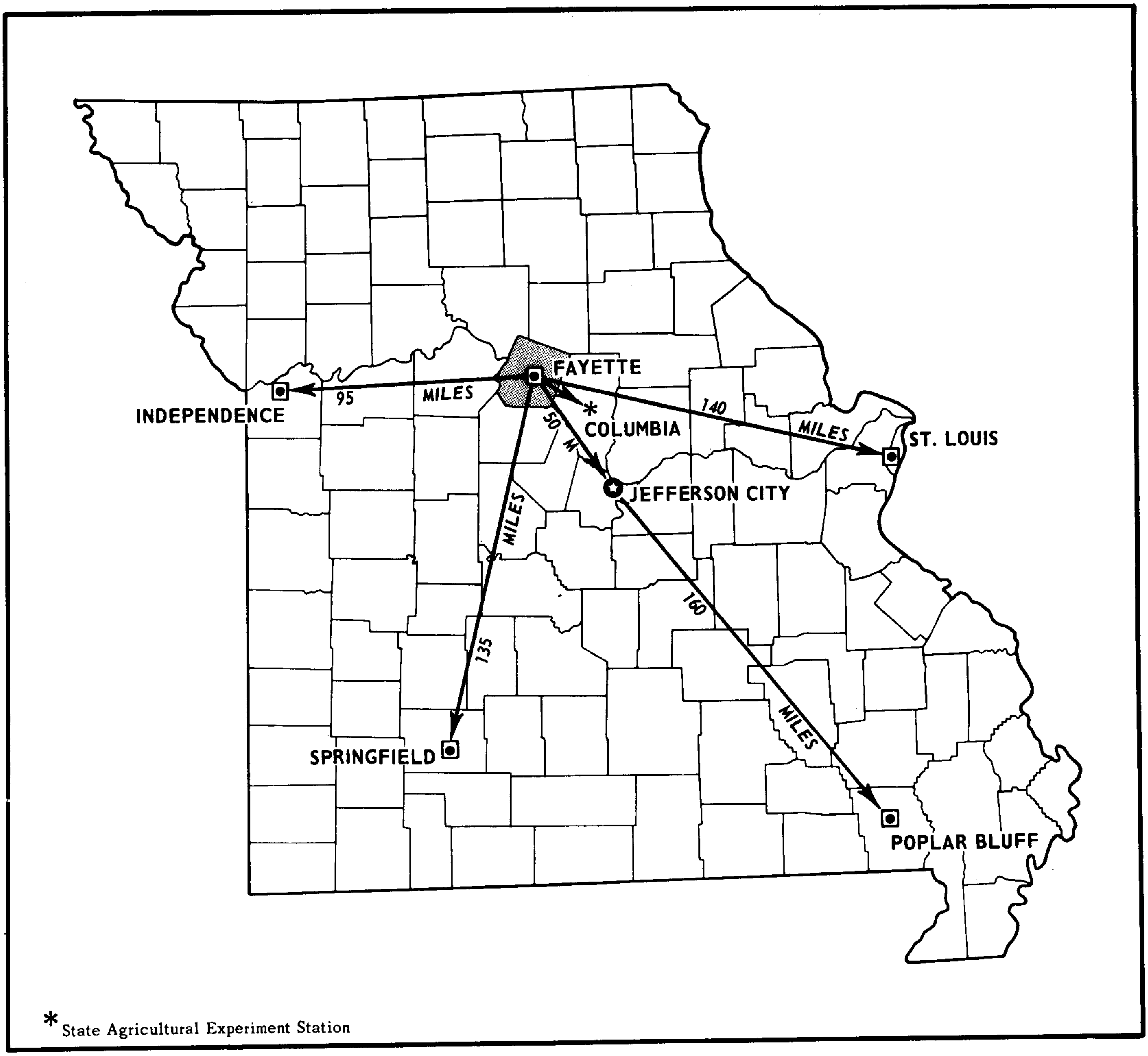
Issued June 1978

Index to Soil Mapping Units

Mapping unit	Page
Br—Bremer silt loam	11
Ca—Carlow silty clay	12
Ch—Chariton silt loam	13
Ed—Edina silt loam	14
Fa—Fatima silt loam	15
Fr—Freeburg silt loam, 0 to 3 percent slopes	16
GaC—Gara and Armstrong loams, 5 to 9 percent slopes	17
GaD—Gara and Armstrong loams, 9 to 14 percent slopes	17
GcC3—Gara and Armstrong clay loams, 5 to 9 percent slopes, severely eroded	17
GnB—Greenton silt loam, 2 to 5 percent slopes	18
GnC—Greenton silt loam, 5 to 9 percent slopes	18
GnD—Greenton silt loam, 9 to 14 percent slopes	19
GrB—Grundy silt loam, 2 to 5 percent slopes	20
GrC—Grundy silt loam, 5 to 9 percent slopes	21
Gu—Gullied land	21
HaB—Hatton silt loam, 2 to 5 percent slopes	22
HaC—Hatton silt loam, 5 to 9 percent slopes	23
Hn—Haynie silt loam	23
Ho—Hodge loamy fine sand	24
KnC—Knox silt loam, 5 to 9 percent slopes	26
KnD3—Knox silt loam, 9 to 14 percent slopes, severely eroded	26
KnE3—Knox silt loam, 14 to 30 percent slopes, severely eroded	26
LaB—Ladoga silt loam, 2 to 5 percent slopes	27
LaC—Ladoga silt loam, 5 to 9 percent slopes	28
Le—Leta silty clay	28
LnE—Lindley loam, 14 to 30 percent slopes	29
LrE3—Lindley clay loam, 14 to 30 percent slopes, severely eroded	30
LsC—Lindley and Keswick loams, 5 to 9 percent slopes	30
LsD—Lindley and Keswick loams, 9 to 14 percent slopes	30
LwD3—Lindley and Keswick clay loams, 9 to 14 percent slopes, severely eroded	31
MaC—Mandeville silt loam, 5 to 9 percent slopes	32
MaD—Mandeville silt loam, 9 to 14 percent slopes	32
MaE—Mandeville silt loam, 14 to 30 percent slopes	32
MbD3—Mandeville silty clay loam, 9 to 14 percent slopes, severely eroded	32
Mc—Marion silt loam	33
MhB—Marshall silt loam, 2 to 5 percent slopes	34
MhC—Marshall silt loam, 5 to 9 percent slopes	34
MkC—McGirk silt loam, 5 to 12 percent slopes	35
MnB—Menfro silt loam, 2 to 5 percent slopes	36
MnC—Menfro silt loam, 5 to 9 percent slopes	36
MnD—Menfro silt loam, 9 to 14 percent slopes	36
MnD3—Menfro silt loam, 9 to 14 percent slopes, severely eroded	37
MnE—Menfro silt loam, 14 to 30 percent slopes	37
MoB—Mexico silt loam, 2 to 5 percent slopes	38
Mu—Moniteau silt loam	39
NaB—Napier silt loam, 2 to 5 percent slopes	40
Nd—Nodaway silt loam	41
NoE—Norris-Rock land complex, 10 to 30 percent slopes	41
PrB—Pershing silt loam, 2 to 5 percent slopes	43
PrC—Pershing silt loam, 5 to 9 percent slopes	43
Rw—Riverwash	43
Sa—Sarpy sand	44
ShB—Sharpsburg silt loam, 2 to 5 percent slopes	45
ShC—Sharpsburg silt loam, 5 to 9 percent slopes	45
WeB—Weller silt loam, 2 to 5 percent slopes	46
WeC—Weller silt loam, 5 to 9 percent slopes	47
WnB—Winfield silt loam, 2 to 5 percent slopes	47
WnC—Winfield silt loam, 5 to 9 percent slopes	48
WnD—Winfield silt loam, 9 to 14 percent slopes	48
WnD3—Winfield silt loam, 9 to 14 percent slopes, severely eroded	48

Summary of Tables

	Page
Descriptions of the Soils	
Approximate acreage and proportionate extent of the soils (Table 1)	10
Use and Management of the Soils	
Predicted average yields per acre of the principal crops (Table 2)	52
Woodland management and productivity (Table 3)	54
Suitability of soils for trees and shrubs for environmental improvement (Table 4)	58
Suitability of soils for elements of wildlife habitat and for classes of wildlife (Table 5)	64
Limitations of soils for recreational developments (Table 6)	68
Engineering Uses of the Soils	
Estimated soil properties significant to engineering (Table 7)	72
Interpretations of engineering properties (Table 8)	78
Formation and Classification of the Soils	
Classification of soils (Table 9)	88
Environmental Factors Affecting Soil Use	
Temperature and precipitation data (Table 10)	91
Probability of last freezing temperature in spring and first in fall (Table 11)	93



Location of Howard County in Missouri.

SOIL SURVEY FOR HOWARD COUNTY, MISSOURI

SURVEY BY HAROLD E. GROGGER AND GILBERT R. LANDTISER, SOIL CONSERVATION SERVICE

FIELDWORK BY C. L. SCRIVNER, PARTY LEADER, M. E. SPRINGER, R. W. FENWICK, GEORGE C. CARTER, MISSOURI AGRICULTURAL EXPERIMENT STATION

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

HOWARD COUNTY is in the central part of Missouri. (See facing page.) The Missouri River marks the southern boundary of the county and a major part of the western boundary line. It is bordered by Chariton County on the northwest and Randolph County on the north. Boone County is on the east side, and Cooper and Saline Counties occupy the opposite banks of the Missouri River to the south and southwest. The total area of the county is about 469 square miles, or 300,160 acres. Fayette, the largest city and county seat, is in the central part of the county. In the 1970 United States Census of Population, Howard County reported 10,561 persons. The total urban population was 3,520.

Farming is the primary enterprise in the county. Most businesses and services pertain to the harvest, storage, and shipping of local farm products. The main types of farming are cash-grain and livestock, mostly beef cattle and hogs. About 92 percent of the county is in farms (1969 United States Census of Agriculture). The major crops are corn, soybeans, wheat, and hay. Some locally important tobacco and tree fruit crops are grown for export. Much of the steep sloping uplands is covered with second growth timber. Some lumbering is done, and most of the lumber is used locally. The gently sloping to moderately sloping prairie areas, the cleared timber areas, and the bottom lands are used extensively for crops and pasture.

The need for erosion control on sloping cropland is the greatest concern in farming upland soils in Howard County. Wetness and the hazard of flooding are the main concerns on bottom land. Soils of the Grundy, Sharpsburg, Greenton, and Marshall series are examples of prairie soils that are susceptible to damage by sheet erosion. Menfro, Winfield, and Knox soils are deep loess soils that are highly subject to severe damage by gullying and sheet erosion. In some areas these soils have been damaged almost beyond reclamation. Examples of upland soils that have varying degrees of wetness problems are those of the Marion, Chariton, and Edina series. The wet soils on bottom land are in the Bremer, Carlow, and Leta series.

In most areas of bottom land and some areas of upland, the soils have a good potential for increased production of crops under supplemental irrigation. Many narrow areas of bottom land along the small streams have a good potential for walnut or other valuable trees. Some areas that have good air drainage have potential for orchards and vineyards.

How This Survey Was Made

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

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

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. Grundy and Knox, for examples, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Menfro silt loam, 5 to 9 percent slopes, is one of several phases within the Menfro 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, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from 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 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. Two such kinds of mapping units are shown on the soil map of Howard County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed 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. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Norris-Rock land complex is an example.

An undifferentiated group is made up of two or more soils that can be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Gara and Armstrong loams is an undifferentiated group in Howard County.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called miscellaneous areas and are given descriptive names. Riverwash is a miscellaneous area in this survey.

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

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current 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 Howard 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.

Descriptions, names, and delineations of soils in this soil survey do not fully agree with soil maps in adjacent counties published at a different date. Differences are the result of better knowledge of soils, modifications in series concepts, intensity of mapping, and the extent of soils within the survey. In places it is more feasible to combine small acreages of similar soils that respond to use and management in much the same way than it is to separate these soils and give them names.

The soil associations in this survey have been grouped into eight general kinds of landscapes for broad interpretative purposes. Each of the broad groups and their included soil associations are described in the following paragraphs.

1. Grundy-Greenton-Sharpsburg Association

Gently sloping to strongly sloping, deep, moderately well drained and somewhat poorly drained soils that have a dominantly moderately fine textured and fine textured subsoil

This association is mainly on broad, gently sloping ridgetops that have moderately sloping, long side slopes (fig. 1). More strongly sloping areas typically border deeply entrenched upland drainageways and narrow bottom lands of the small creeks and their tributaries.

The soils formed in moderately thick deposits of loess underlain by glacial till or residuum from clay shale and interbedded limestone. The native vegetation is mainly tall prairie grass.

This association occupies about 11 percent of the county. Grundy soils make up about 30 percent of the association, Greenton soils about 30 percent, Sharpsburg soils about 24 percent, and the remaining minor soils 16 percent.

Grundy soils are gently sloping on the wider ridgetops and moderately sloping on the upper parts of side slopes. These soils have a very dark brown silt loam surface layer about 11 inches thick. The subsurface layer is very dark brown silty clay loam. The subsoil is very dark gray, dark grayish brown, and light brownish gray silty clay. It has yellowish brown mottles at a depth of about 24 inches. Below a depth of 42 inches it is mottled, grayish brown and yellowish brown silty clay loam. Grundy soils are somewhat poorly drained. Permeability is slow, and available water capacity is high.

Greenton soils are gently sloping to strongly sloping. They are on lower parts of side slopes and on pointlike crests at the ends of ridges. These soils have a very dark grayish brown silt loam surface layer. The layer below this is very dark gray. The combined thickness of these 2 layers is about 12 inches. The upper part of the subsoil is dark brown and dark yellowish brown silty clay that has light brownish gray mottles, and the lower part is mottled light brownish gray and yellowish brown clay. The subsoil is underlain by weathered soft silty and clayey shale that contains many small pieces of limestone at a depth of about 42 inches. Greenton soils are moderately well drained. Permeability is slow, and available water capacity is moderate.

Sharpsburg soils are on narrow convex ridgetops and the uppermost parts of side slopes. The Sharps-

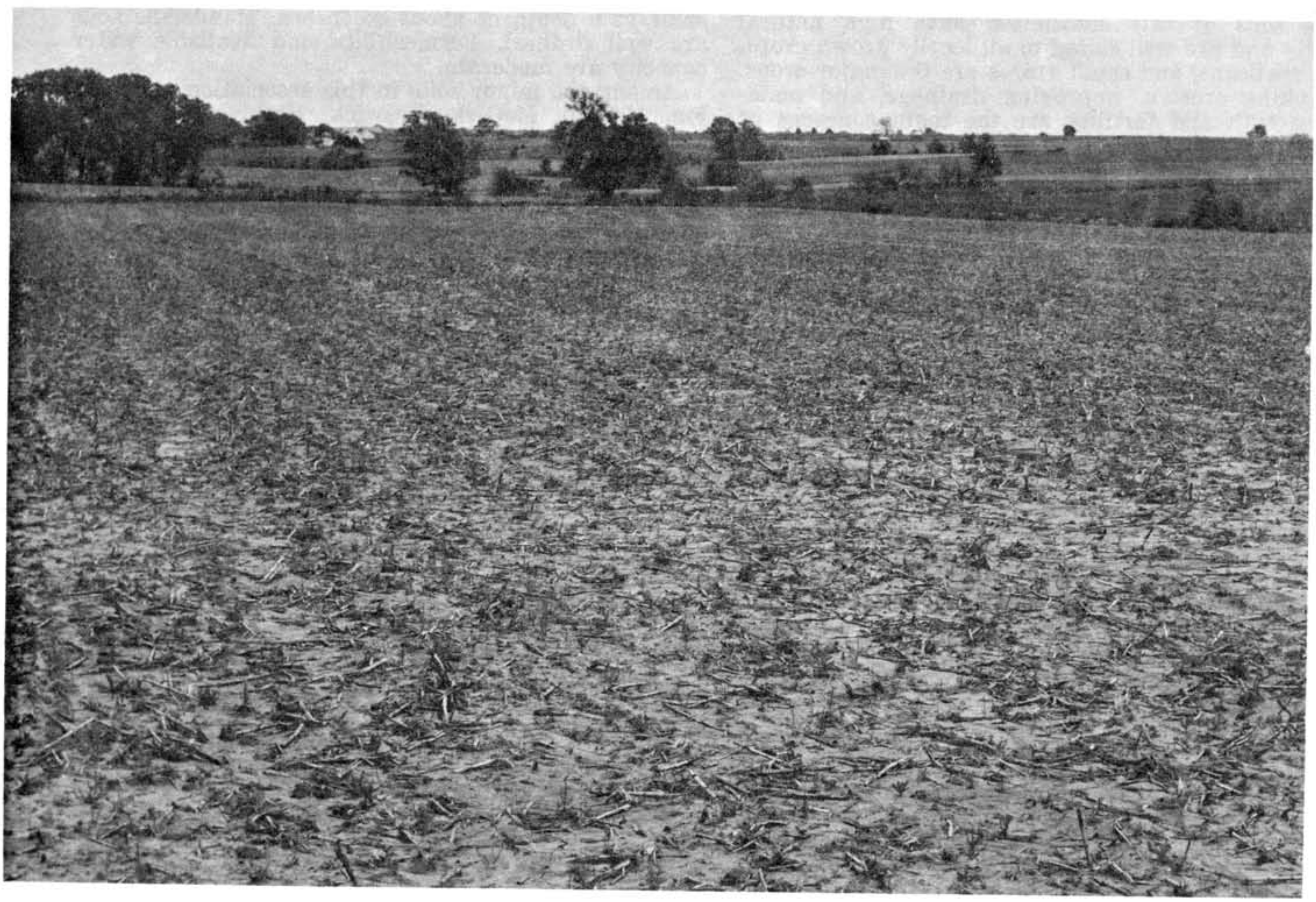


Figure 1.—**A typical landscape of the Grundy-Greenton-Sharpsburg association.**

burg soils on ridgetops are gently sloping; those on side slopes are moderately sloping. The surface layer is very dark brown silt loam about 11 inches thick. The upper part of the subsoil is very dark brown and very dark grayish brown silt loam and silty clay loam, and the middle part is dark brown silty clay loam. The lower part is dark grayish brown silty clay loam with light olive brown and yellowish brown mottles. The subsoil is underlain by grayish brown silt loam at a depth of about 38 inches. Sharpsburg soils are moderately well drained. Permeability is moderately slow, and available water capacity is high.

Among the minor soils in this association are Armstrong, Edina, Gara, and Pershing.

Armstrong soils are mapped with Keswick soils. They both formed in glacial till. They are moderately sloping to strongly sloping and are in positions below Sharpsburg and Grundy soils. Edina soils formed in loess. They are poorly drained soils in nearly level or slightly concave areas on wide flattop ridges and in the upper parts of drainageways. They usually border or are surrounded by Grundy soils. Pershing soils are similar to Grundy soils but formed under a vegetation of grasses and trees. They lack the thick dark surface and subsurface layers of the major soils of this association.

The soils of this association have high natural fertility and are well suited to all locally grown crops. Corn, soybeans, and small grains are the major crops. Controlling erosion, improving drainage, and maintaining tilth and fertility are the main concerns of management.

2. Winfield-Lindley-Mandeville Association

Gently sloping to steep, deep and moderately deep, well drained and moderately well drained soils that have a dominantly moderately fine textured subsoil

This association is on long, narrow, and moderately wide ridges that have highly dissected, irregularly shaped side slopes. The ridgetops are convex and gently sloping to moderately sloping, and the side slopes are strongly sloping to steep. Drainageways are well defined to deeply entrenched. Differences in elevation from the top of ridges to the valleys of the small streams range from about 100 to 200 feet. The soils on ridgetops and on upper parts of side slopes formed in thick deposits of loess. The soils on lower parts of side slopes formed in glacial till or residuum from soft, silty and clayey shale. The native vegetation is hardwood forest.

This association occupies about 28 percent of the county. Winfield soils make up about 30 percent of the area, Lindley soils about 20 percent, Mandeville soils about 15 percent, and minor soils the remaining 35 percent.

Winfield soils formed in deep loess. They are gently sloping to strongly sloping soils on ridgetops and upper parts of side slopes. The surface layer is dark grayish brown silt loam. The subsoil is brown silty clay loam that has light brownish gray mottles at a depth of about 28 inches. It has mottled light brownish gray and yellowish brown heavy silt loam below a depth of 40 inches. Winfield soils are moderately well drained. Permeability is moderate, and available water capacity is very high.

Lindley soils are mapped with Keswick soils. Lindley soils formed in glacial till. They are moderately sloping to strongly sloping on side slopes and next to and below Keswick soils. Keswick soils are on side slopes below Winfield soils and are generally above the Mandeville soils. Lindley soils have a dark grayish brown loam surface layer and a brown loam subsurface layer. The combined thickness of the 2 layers is about 7 inches. The subsoil is strong brown clay loam underlain by mottled yellowish brown and light brownish gray clay loam at a depth of about 46 inches. Lindley soils are well drained. Permeability is moderately slow, and available water capacity is moderate.

Mandeville soils formed in residuum that weathered from shale and interbedded limestone. They are moderately sloping to steep soils on ridgetops and side slopes. They commonly occur on side slopes below Lindley and Keswick soils and above areas of rock outcrops and escarpments. Mandeville soils have a dark brown silt loam surface layer and a brown silt loam subsurface layer. The combined thickness of the two layers is about 8 inches. The subsoil is dark yellowish brown to brown silty clay loam. It is underlain by light olive brown, soft weathered silty and clayey shale at a depth of about 35 inches. Mandeville soils are well drained. Permeability and available water capacity are moderate.

Among the minor soils in this association are Marion, Menfro, McGirk, Keswick, Norris, and Weller soils. The Keswick series is the most important minor soil in this association. It is mapped with Lindley soils. Keswick soils formed in old glacial till. They are in narrow bands or strips on side slopes above Lindley soils and below the Winfield soils that are on ridgetops.

Marion soils formed in loess and are poorly drained. They occupy small flat areas on some ridgetops and on old high terraces. Menfro soils formed in deep loess and are the most extensive of the minor soils in this association. They occupy areas on narrow ridgetops slightly higher than those of Winfield soils and are in similar positions to Winfield soils on side slopes. They have better drainage and more rapid runoff than Winfield soils. McGirk soils are somewhat poorly drained and are on foot slopes below Winfield and Menfro soils. Norris soils are shallow and are underlain by shale bedrock at a depth of 20 inches or less. They are typically on side slopes below Mandeville soils or on crests of ridges and slopes near rock outcrop and escarpments. Weller soils occur on rounded ridgetops and convex side slopes at the upper ends of the drainageways. Typically, they are slightly below Winfield and above Lindley and Keswick soils.

Cultivated areas of this association are mainly the larger areas of gently sloping and moderately sloping Winfield soils. The main crops are corn, soybeans, small grains, and hay. Lindley and Keswick soils, and areas of Mandeville soils, are used mostly as pasture for beef cattle and hogs or remain wooded. The main concerns in use and management of cultivated areas are control of water erosion and maintenance of tilth and fertility. Wooded areas are better suited to wildlife habitat, recreation, and timber than to other uses.

3. Menfro-Lindley-Norris Association

Gently sloping to steep, deep and shallow, well drained soils that have a dominantly moderately fine textured subsoil

This association is on the river hills and bluffs bordering the Missouri River and its flood plain. It has high, narrow topped, fingerlike ridges that have long irregularly shaped side slopes and well defined drainageways. The ridgetops are convex and gently sloping to moderately sloping. The side slopes are moderately sloping to steep. The area is dissected by many small, deeply entrenched streams and creeks that flow directly into the Missouri River. Differences in elevations from the tops of ridges to the bottom land of the nearest streams range from about 120 to 250 feet. The soils formed in deep loess, glacial till, and residuum from shale and interbedded limestone, but a small acreage is underlain by bedrock at a depth of less than 20 inches. The native vegetation is hardwood forests.

This association occupies about 12 percent of the county. Menfro soils make up about 60 percent of the association, Lindley and Norris soils about 10 percent each, and minor soils about 20 percent.

Menfro soils formed in deep loess. They are gently sloping to steep soils on ridgetops and side slopes. They have a dark grayish brown silt loam surface layer and a dark brown silt loam subsurface layer. The combined thickness of the two layers is about 10 inches. The subsoil is dark brown silty clay loam. It is underlain by yellowish brown silty clay loam at a depth of about 46 inches. Menfro soils are well drained. Permeability is moderate, and available water capacity is high.

Lindley soils formed in glacial till. They are strongly sloping to steep and are on the lower parts of side slopes below Menfro soils. They are above Norris soils in places where both occupy similar positions on the landscape. Lindley soils have a dark grayish brown loam surface layer and a brown loam subsurface layer. The combined thickness of the two layers is about 7 inches. The subsoil is strong brown clay loam underlain by mottled, yellowish brown and light brownish gray clay loam at a depth of about 46 inches. Lindley soils are well drained. Permeability is moderately slow, and available water capacity is moderate.

Norris soils formed in residuum weathered from soft shale. They are strongly sloping to steep soils on the lower parts of side slopes below Menfro and Lindley soils and next to areas of rock outcrop and escarpments. Norris soils have a thin very dark grayish brown silt loam surface layer about 3 inches thick. The subsoil is yellowish brown silt loam. It is underlain by thin interbedded lenses of light olive brown silty clay loam and soft weathered shale at a depth of about 13 inches. Norris soils are shallow and well drained. Permeability is moderate, and available water capacity is very low.

Among the minor soils in this association are Mandeville, McGirk, and Winfield soils. Mandeville soils formed in residuum weathered from shale and interbedded limestone. They are moderately deep soils on lower parts of side slopes below Menfro and Lindley soils and generally above Norris soils.

McGirk soils formed in sediment eroded from the adjoining and higher uplands. They occur below Menfro soils and usually above areas of Lindley soils.

Winfield soils formed in deep loess. They are on ridgetops and side slopes. In areas where Winfield, Menfro, and Lindley soils are together in the landscape, Winfield soils are below Menfro soils and above Lindley soils.

Cultivated areas of this association are mainly in the larger areas of gently sloping and moderately sloping Menfro soils. The main crops are corn, soybeans, small grains, and hay. Most areas of steeper soils are used as pasture for beef cattle and hogs, but some of these areas are wooded. The hazard of erosion is severe. Several large tracts of land have been destroyed by severe gully erosion, and they are unsuitable for most uses. Maintaining tilth and fertility, controlling erosion, and improving pasture are the main management concerns.

4. Lindley-Hatton-Mandeville Association

Gently sloping to steep, deep to shallow, well drained and moderately well drained soils that have a dominantly moderately fine textured and fine textured subsoil

This association is mainly on four large, long, wide bottomed and narrow topped ridges. These ridges extend in a northeast to southwest direction, and their tops are at relatively the same elevation. They represent a remnant surface of an old glacial till plain. The ridges are gently sloping to moderately steep, but they have many riblike projections that extend from the narrow center crest at different angles. These projections have highly complex and irregularly shaped, moderately sloping to steep side slopes. The side slopes are about 200 to 1,000 feet long. Differences in elevation from the tops of ridges to the bottom land of the nearest streams range from about 80 to 150 feet.

The soils formed mainly in glacial till, but some formed in a thin mantle of loess and the underlying glacial till and others in residuum from shale and interbedded limestone. Some of the soils are underlain by bedrock at a depth of 10 to 40 inches. The native vegetation is hardwood forests.

This association occupies about 12 percent of the county. Lindley soils make up about 40 percent of the association, Hatton soils about 10 percent, Mandeville soils about 10 percent, and minor soils the remaining 40 percent.

Lindley soils formed in glacial till. They are moderately sloping to steep soils on upper parts of side slopes. In many places they cover the entire slope. These soils are below Hatton soils and above Mandeville and Norris soils. Lindley soils have a dark grayish brown loam surface layer and a brown loam subsurface layer. The combined thickness of the two layers is about 7 inches. The subsoil is strong brown clay loam underlain by mottled, yellowish brown and light brownish gray clay loam at a depth of about 46 inches. Lindley soils are well drained. Permeability is moderately slow, and available water capacity is moderate.

Hatton soils formed in a thin mantle of loess and the underlying glacial till. They are gently sloping to moderately sloping and are on the narrow ridgetops above the Lindley soils. These soils have a thin, dark grayish brown silt loam surface layer about 3 inches thick and a light yellowish brown silt loam subsurface layer about 5 inches thick. The upper part of the subsoil is strong brown and brown silty clay loam, and the lower part is dark brown silty clay that has grayish brown mottles. The subsoil is underlain by a mottled, yellowish brown and grayish brown silty clay loam fragipan at a depth of about 37 inches. Hatton soils are moderately well drained. Permeability is very slow, and available water capacity is moderate.

Mandeville soils formed in residuum from shale. These moderately sloping to steep soils are on ridgetops and side slopes. Generally, they are below the Lindley soils and above the Norris soils. Mandeville soils have a dark brown silt loam surface layer and a brown silt loam subsurface layer. The combined thickness of the two layers is about 8 inches. The subsoil is dark yellowish brown to brown silty clay loam. It is underlain by light olive brown, soft, weathered silty and clayey shale at a depth of about 35 inches. Mandeville soils are well drained. Permeability and available water capacity are moderate.

Among the minor soils in this association are Armstrong, Gara, Keswick, Marion, Mexico, Norris, and Weller. Norris soils are the most extensive; they make up about 10 percent of the association. Norris soils are on side slopes below Mandeville soils and on narrow ridges and ends of ridges bordering the deeply entrenched valleys of small streams.

Armstrong soils are mapped with Gara soils. Together they are on upper parts of side slopes above Lindley soils. They usually border areas of soils that formed under tall-grass prairie. Keswick soils are mapped with Lindley soils. They are on side slopes in positions similar to those of Lindley soils. Marion and Weller soils are on narrow ridgetops in positions similar to those of Hatton soils. Mexico soils are in high, isolated, tabletop areas above Hatton and Lindley soils.

Because of steep and complex slopes, the soils of this association are not excessively cultivated. In places, corn, soybeans, small grains, and hay are grown in small areas of gently sloping to moderately sloping soils. Stronger sloping soils are used mainly for pasture or remain wooded. Improvement of pasture and use of wooded areas for wildlife, recreation, and timber production are the main concerns of management.

5. Knox-Marshall Association

Gently sloping to steep, deep, well drained soils that have a moderately fine textured subsoil

This association is mainly on river hills and bluffs bordering the Missouri River and its flood plain. It has many high, narrow topped, fingerlike ridges that have long, irregularly shaped side slopes and well defined drainageways. The ridgetops are convex and gently sloping to moderately sloping. The side slopes are moderately sloping to steep. The area is dissected by many small, steeply entrenched streams and creeks that flow directly into the Missouri River. Differences in elevation from the tops of ridges to the bottom land of the nearest streams range from about 120 to 250 feet. The soils formed in deep loess under native vegetation of tall prairie grass, other prairie grasses, and trees (fig. 2).

Figure 2.—**Vertical road cuts in deep loess soils of the Knox-Marshall association. The loess deposit is over 20 feet thick in most of this area.**

This association occupies about 5 percent of the county. Knox soils make up about 54 percent of the association, Marshall soils about 26 percent, and minor soils about 20 percent.

Knox soils formed in deep loess on rounded ridgetops and side slopes. They are moderately sloping to steep. These soils have a dark brown silt loam surface layer about 11 inches thick. The subsoil is dark yellowish brown heavy silt loam. It is underlain by yellowish brown silt loam at a depth of about 38 inches. Knox soils are well drained. Permeability is moderate, and available water capacity is high.

Marshall soils formed in deep loess on the higher and wider ridgetops and on upper parts of side slopes. They are gently sloping to moderately sloping. These soils generally are farther north of the Missouri River than Knox soils. Marshall soils have a very dark grayish brown silt loam surface layer about 13 inches thick. The upper part of the subsoil is dark brown silt loam, and the lower part is dark yellowish brown silty clay loam. The subsoil is underlain by yellowish brown silt loam at a depth of about 35 inches. Marshall soils are well drained. Permeability is moderate, and available water capacity is high.

Among the minor soils in this association are Menfro and Norris. Menfro soils formed in deep loess. They are gently sloping to steep and are on ridgetop and on side slope positions similar to those of Knox soils. The native vegetation is hardwood forest.

Norris soils formed in residuum weathered from shale bedrock. They are shallow, strongly sloping to steep soils near rock outcrops and escarpments and on lower parts of side slopes below Knox soils.

The soils of this association have high natural fertility and are well suited to all locally grown crops. The main crops are corn, soybeans, small grains, and grass-legume hay. These soils have been intensively cultivated in the past and most are severely eroded. The main management concerns are controlling erosion, maintaining tilth and fertility, and converting the more strongly sloping soils for less intensive uses.

6. Gara-Weller-Ladoga Association

Gently sloping to strongly sloping, deep, mainly moderately well drained soils that have a moderately fine textured and fine textured subsoil

This association is on moderately high, wide topped ridges that have long, moderately sloping to strongly sloping side slopes. The ridgetops are typically about 300 to 400 feet wide, and the side slopes are about 700 to 1,000 feet long. Differences in elevation from the tops of ridges to the bottom land of the nearest small stream ranges from about 50 to 100 feet. Areas of more steeply sloping soils usually border the narrow valleys of the main creeks and their tributaries. The soils of this association were formed mainly in glacial till or in a thin to moderately thick mantle of loess underlain by glacial till. The native vegetation is prairie grasses and trees on most of the area and a dense hardwood forest on the remaining part.

This association occupies about 16 percent of the county. Gara soils make up about 30 percent of the area, Weller soils about 20 percent, Ladoga soils about 15 percent, and minor soils about 35 percent.

Gara soils occur in intricate patterns on the landscape with Armstrong soils. Both soils formed in glacial till. Gara soils are moderately sloping to strongly sloping. They are on side slopes below Armstrong soils. They have a very dark brown loam surface layer about 2 inches thick and a dark brown loam subsurface layer about 9 inches thick. The upper part of the subsoil is dark brown and dark yellowish brown clay loam and the lower part is dark brown and yellowish brown clay loam with grayish brown mottles. The subsoil is underlain by mottled, yellowish brown and grayish brown clay loam at a depth of 42 inches. Gara soils are moderately well drained. Permeability is moderately slow, and available water capacity is high.

The Weller soils are gently sloping to moderately sloping. They are on side slopes and ridgetops of uplands. These soils have a dark grayish brown silt loam surface layer about 7 inches thick. The subsurface layer is about 4 inches of brown silt loam. The upper part of the subsoil is a dark yellowish brown clay loam grading to silty clay at a depth of 16 inches. The lower part of the subsoil is a brownish gray silty clay with yellowish brown mottles. Weller soils are moderately well drained. Permeability is moderately slow, and available water capacity is high.

Ladoga soils formed in loess. They are gently sloping to moderately sloping. These soils are on the highest parts of ridgetops and the uppermost parts of convex side slopes. They usually are higher than the other soils of the association and higher than any other soils in the immediate landscape. These soils have a very dark grayish brown silt loam surface layer about 7 inches thick and a dark grayish brown silt loam subsurface layer about 4 inches thick. The upper part of the subsoil is dark brown silty clay loam, the middle part is grayish brown silty clay loam, and the part below a depth of 56 inches is grayish brown silt loam. Ladoga soils are moderately well drained. Permeability is moderately slow, and available water capacity is high.

Among the minor soils in this association are Armstrong, Greenton, Grundy, Keswick, Lindley, Mandeville, Pershing and Sharpsburg. Armstrong and Pershing soils are the most prevalent of the minor soils in this association. Armstrong soils formed in old glacial till. Armstrong soils occur in intricate patterns on the landscape with Gara soils. They occupy narrow, convex shoulders and upper parts of side slopes and rounded, low ridgetop and pointlike ends of ridges. Pershing soils formed in loess. They are gently to moderately sloping soils on ridgetops and on narrow, rounded ends of ridges.

Greenton soils are moderately sloping and are on the wider topped ridges. They are generally near and above Mandeville soils that are moderately deep to bedrock and are below Weller soils. They formed under a vegetation of tall prairie grass. Grundy soils are also prairie soils that formed in loess. They are gently sloping and are on the tops of the wider topped ridges in positions similar to those of Ladoga soils. Keswick and Lindley soils were mapped together in this survey. Both formed in glacial till. They occupy areas on side slopes above Gara and Armstrong soils and below Ladoga, Weller, and Pershing soils.

Mandeville soils formed in residuum derived from shale. They are in low side slope positions below Gara and Armstrong soils. Sharpsburg soils formed in loess under a vegetation of tall prairie grass. They are in positions on ridgetops similar to those of Ladoga soils.

The soils in this association have medium to high natural fertility and are suited to most locally adapted crops. The main crops are corn, soybeans, small grains, and hay (fig. 3). Most Gara and Armstrong soils are used as pasture for beef cattle and hogs. Areas of steeper soils along the drainageways are wooded. Controlling erosion, maintaining and improving tilth and fertility, and improving drainage are the main concerns of management.

7. Leta-Haynie-Hodge Association

Level to nearly level, deep, well drained and somewhat poorly drained soils that have stratified, coarse textured to fine textured material below the surface layer

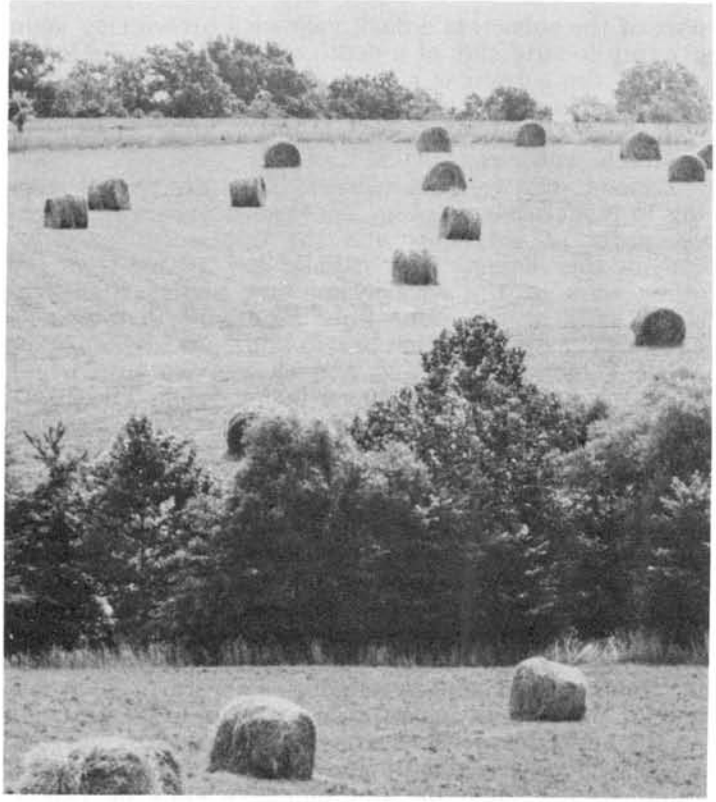


Figure 3.—**Hayland area of the Gara-Weller-Ladoga association.**

This association is on terraces and bottom lands of the Missouri River. The soils are level to nearly level and are marked by remnants of old channels, natural levees, and sloughs left by past flooding and meandering of the river. The soils formed in alluvial sediment from many different sources. They are sandy to clayey. The native vegetation is marsh grasses and reeds and willow, cottonwood, and oak trees.

This association occupies about 10 percent of the county. Leta soils make up about 42 percent of the association, Haynie soils about 24 percent, Hodge soils about 12 percent, and minor soils the remaining 22 percent.

Leta soils are level to nearly level. They are on broad flats or in slightly concave, old slack water areas and stream channels. They have a very dark grayish brown silty clay surface layer about 7 inches thick and a very dark gray silty clay subsurface layer about 12 inches thick. The subsoil is very dark grayish brown silty clay with dark gray and dark yellowish brown mottles. It is underlain by dark gray and grayish brown silt loam at a depth of 34 to 40 inches and by dark grayish brown clay at a depth of more than 40 inches. Leta soils are somewhat poorly drained. Permeability is slow, and available water capacity is moderate.

Haynie soils are nearly level. They are on very low mounds and ridgelike natural levees that have slightly convex slopes; in large, nearly level, single gradient areas; and in slightly undulating areas. They have a very dark grayish brown silt loam surface layer about 7 inches thick. The subsoil is stratified brown and dark grayish brown silt loam and very fine sandy loam. Haynie soils are well drained. Permeability is moderate, and available water capacity is high.

Hodge soils are level to nearly level and are near active river channels or along the edges of old abandoned channels. Some areas of the landscape are broad, slightly convex mounds, and others are very low, narrow, convex ridgelike natural levees. The most recent overflow and overtoppings of constructed levees are in a typical area. Hodge soils have a dark grayish brown loamy fine sand surface layer about 9 inches thick. The subsoil is dark grayish brown and brown loamy fine sand. Hodge soils are well drained. Permeability is rapid, and available water capacity is low.

Among the minor soils in this association are Bremer, Carlow, Nodaway, and Sarpy.

Bremer soils occupy slightly higher terrace positions on the flood plain and usually occur next to foot slopes of the valley bluffs. Carlow soils occupy the low wet sloughs and depressions of old slack water areas. Nodaway soils are along the bluffs where the tributary streams outlet onto the Missouri Valley floor. They form deltalike deposits at the mouths of the smaller streams and along the parts of these meandering streams that are closest to the valley bluffs. The Sarpy soils occur in positions similar to those of the Hodge soils that are near the active Missouri River channel, or are in old abandoned channels of relatively recent age.

The soils in this association range from low to medium in fertility, but they are some of the most productive soils in the county because of their nearly level topography and ease of tilling, planting, and harvesting. The most serious problem is the constant threat of flooding. Although many areas are protected by large constructed levees, breakthroughs and overtoppings are common. Leta and Haynie soils are well suited to all locally adapted crops and are planted mostly in corn and soybeans. The other soils are either less productive or wetter but are used for corn, soybeans, and small grain. The main management concerns are to improve and maintain tilth and fertility, improve drainage, and prevent or control flooding.

8. Nodaway-Fatima-Bremer Association

Level to nearly level, deep, moderately well drained and poorly drained soils that have a stratified, moderately fine textured and medium textured subsoil

This association is on level to nearly level terraces and bottom lands of the streams, creeks, and smaller rivers of the county. These streams and their valleys form a complex network of drainageways that flow directly into the Missouri River. The valleys and flood plains are relatively narrow and are deeply entrenched. The soils formed in alluvium derived from the nearby uplands. The native vegetation of these areas ranged from trees and shrubs to wetland grasses, sedges, and tall prairie grass.

This association occupies about 6 percent of the county. Nodaway soils make up about 50 percent of the association, Fatima soils about 25 percent, Bremer soils about 15 percent, and minor soils about 10 percent.

Nodaway soils formed in alluvial sediment that had a cover of trees and grasses. They are level to nearly level soils on bottom land positions nearest to the active stream channel. They have a dark brown silt loam surface layer about 8 inches thick. The subsoil is stratified brown, dark grayish brown, and very dark gray silt loam with dark grayish brown and dark gray mottles. The native vegetation is trees and grasses. Nodaway soils are moderately well drained. Permeability is moderate, and available water capacity is high.

Fatima soils formed in alluvium. These soils are level to nearly level. They are next to streams in the narrow bottom lands that finger into the uplands, and they are in open areas, both next to the stream and in nearby places in the wider bottoms of the larger streams and creeks. These soils have a very dark grayish brown silt loam surface layer about 10 inches thick. The subsoil is stratified dark brown and dark grayish brown silt loam with dark gray, gray, and yellowish brown mottles. The native vegetation is trees and grasses. Fatima soils are moderately well drained. Permeability is moderate, and available water capacity is very high.

Bremer soils formed in alluvial sediment. They are level to nearly level soils in slightly higher benchlike terraces and second bottom positions of the wide bottom lands and on the upper, headwater parts of narrow bottoms. They have a very dark gray silt loam surface layer about 8 inches thick. The upper part of the subsoil is very dark gray silty clay loam, and the lower part is dark gray silty clay loam. The subsoil is underlain by dark gray silty clay loam at a depth of about 44 inches. The native vegetation is tall prairie grasses. Bremer soils are poorly drained. Permeability is slow, and available water capacity is high.

Among the minor soils in this association are Carlow, Freeburg, and Moniteau. Carlow soils are in low, wet, slightly concave depressions or slack water areas of the wider bottom lands. Freeburg soils usually are on the second bottoms, low terraces, and benchlike areas of the small, narrow bottomed streams. They are typically next to the upland valley side slopes. Moniteau soils occupy terrace and second bottom positions on flood plains of the larger creeks and streams. They are wetter than similarly positioned Freeburg soils on terraces and generally occur in large areas throughout the flood plain.

The soils of this association are subject to frequent flooding. The major flooding occurs early in spring. The small streams that have narrow bottom lands and steep valley side slopes usually have frequent flash floods of short duration. The larger creeks that have the wider flood plains are subject to flooding for periods of several days to a week or more.

These soils are planted to corn and soybeans in most years. Areas that are too small, isolated, narrow, or irregularly shaped for cultivation are pastured, wooded, or left idle. These soils have high natural fertility. The main management concerns in cultivated areas are maintaining tilth and fertility, improving drainage, and flood control.

Descriptions of the Soils

In this section the soils of Howard County are described in detail and their use and management are discussed. Each soil series is described in detail, and then, briefly, the mapping units in that series. Unless it is specifically mentioned otherwise, one can assume that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. The profile described in the soil series is representative of mapping units in that series. If a given mapping unit has a profile that in some ways differs from the one described in the series, these differences are stated in the description of the mapping unit, or they are apparent in the name of the mapping unit. The description of each mapping unit contains suggestions on how the soil can be managed.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Riverwash, for example, does not belong to a soil series, but nevertheless is listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The page for the description of each mapping unit can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*10*).[1]

Armstrong Series

The Armstrong series consists of deep, moderately well drained, moderately sloping to strongly sloping soils on uplands. These soils formed in thin loess deposits and the underlying weathered glacial till on old glacial till plains. The native vegetation is prairie grasses and deciduous trees.

In a representative profile the surface layer is very dark grayish brown loam about 9 inches thick. The subsurface layer is yellowish brown loam about 3 inches thick. The subsoil, to a depth of 60 inches, is firm clay loam. The upper part of the subsoil is dark yellowish brown and reddish brown, the middle part

[1] Italicized numbers in parentheses refer to references, page 91.

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

Soil	Acres	Percent
Bremer silt loam	10,150	3.4
Carlow silty clay	4,350	1.5
Chariton silt loam	3,350	1.1
Edina silt loam	500	.2
Fatima silt loam	7,900	2.7
Freeburg silt loam, 0 to 3 percent slopes	2,750	1.0
Gara and Armstrong loams, 5 to 9 percent	14,100	4.7
Gara and Armstrong loams, 9 to 14 percent slopes	3,100	1.0
Gara and Armstrong clay loams, 5 to 9 percent slopes, severely eroded	2,550	.8
Greenton silt loam, 2 to 5 percent slopes	1,000	.3
Greenton silt loam, 5 to 9 percent slopes	9,300	3.1
Greenton silt loam, 9 to 14 percent slopes	1,250	.4
Grundy silt loam, 2 to 5 percent slopes	8,850	3.0
Grundy silt loam, 5 to 9 percent slopes	3,600	1.2
Gullied land	1,150	.4
Hatton silt loam, 2 to 5 percent slopes	1,100	.4
Hatton silt loam, 5 to 9 percent slopes	2,950	1.0
Haynie silt loam	7,350	2.4
Hodge loamy fine sand	3,800	1.3
Knox silt loam, 5 to 9 percent slopes	2,100	.7
Knox silt loam, 9 to 14 percent slopes, severely eroded	2,750	.9
Knox silt loam, 14 to 30 percent slopes, severely eroded	4,650	1.5
Ladoga silt loam, 2 to 5 percent slopes	3,350	1.1
Ladoga silt loam, 5 to 9 percent slopes	4,150	1.4
Leta silty clay	12,800	4.3
Lindley loam, 14 to 30 percent slopes	13,700	4.6
Lindley clay loam, 14 to 30 percent slopes, severely eroded	3,100	1.0
Lindley and Keswick loams, 5 to 9 percent slopes	4,150	1.4
Lindley and Keswick loams, 9 to 14 percent slopes	7,150	2.4
Lindley and Keswick clay loams, 9 to 14 percent slopes, severely eroded	7,800	2.6
Mandeville silt loam, 5 to 9 percent slopes	1,700	.6
Mandeville silt loam, 9 to 14 percent slopes	9,300	3.1
Mandeville silt loam, 14 to 30 percent slopes	4,250	1.4
Mandeville silty clay loam, 9 to 14 percent slopes, severely eroded	1,450	.5
Marion silt loam	1,250	.4
Marshall silt loam, 2 to 5 percent slopes	3,350	1.1
Marshall silt loam, 5 to 9 percent slopes	2,300	.8
McGirk silt loam, 5 to 12 percent slopes	4,000	1.3
Menfro silt loam, 2 to 5 percent slopes	900	.3
Menfro silt loam, 5 to 9 percent slopes	9,350	3.1
Menfro silt loam, 9 to 14 percent slopes	3,950	1.3
Menfro silt loam, 9 to 14 percent slopes, severely eroded	2,400	.8
Menfro silt loam, 14 to 30 percent slopes	9,280	3.1
Mexico silt loam, 2 to 5 percent slopes	650	.2
Moniteau silt loam	1,950	.6
Napier silt loam, 2 to 5 percent slopes	950	.3
Nodaway silt loam	19,600	6.5
Norris-Rock land complex, 10 to 30 percent slopes	11,700	3.9
Pershing silt loam, 2 to 5 percent slopes	4,050	1.3
Pershing silt loam, 5 to 9 percent slopes	1,500	.5
Riverwash	750	.2
Sarpy sand	830	.3
Sharpsburg silt loam, 2 to 5 percent slopes	5,500	1.8
Sharpsburg silt loam, 5 to 9 percent slopes	3,700	1.2
Weller silt loam, 2 to 5 percent slopes	2,300	.8
Weller silt loam, 5 to 9 percent slopes	8,950	3.0
Winfield silt loam, 2 to 5 percent slopes	2,100	.7
Winfield silt loam, 5 to 9 percent slopes	19,700	6.6
Winfield silt loam, 9 to 14 percent slopes	3,700	1.2
Winfield silt loam, 9 to 14 percent slopes, severely eroded	3,650	1.2
Strip mines	300	.1
Total	300,160	100.0

is dark brown and yellowish brown with grayish brown and gray mottles, and the lower part is mottled yellowish brown and gray.

Permeability is slow, and available water capacity is moderate. These soils have a perched water table in the winter and spring. The subsoil has high shrink-swell potential.

Many areas of these soils are cleared. They are used mainly for hay and pasture, but in some areas corn and sorghum are grown. Natural fertility is medium in areas where the soil is uneroded and low in areas where it is eroded. Wooded areas are made up mostly of second growth oak and hickory.

Representative profile of Armstrong loam in an area of Gara and Armstrong loams, 5 to 9 percent slopes, in bluegrass pasture about 2,600 feet north and 1,400 feet east of the southwest corner of sec. 11, T. 50 N., R. 15 W.:

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) loam; weak fine granular structure; friable; medium acid; clear smooth boundary.

A2—9 to 12 inches; yellowish brown (10YR 5/4) loam; moderate medium granular structure; friable; strongly acid; abrupt smooth boundary.

B1—12 to 15 inches; dark yellowish brown (10YR 4/4) light clay loam; moderate fine subangular blocky structure; patchy reddish brown (5YR 4/4) clay films on ped faces; firm; medium acid; clear smooth boundary.

IIB21t—15 to 22 inches; dark brown (7.5YR 4/4) heavy clay loam; common fine distinct grayish brown (10YR 5/2) mottles; moderate medium subangular blocky structure; continuous reddish brown (5YR 4/4) clay films on ped faces; firm; strongly acid; gradual smooth boundary.

IIB22t—22 to 32 inches; yellowish brown (10YR 5/6) heavy clay loam; common medium distinct gray (10YR 6/1) mottles; weak medium subangular blocky structure; common reddish brown (5YR 4/4) clay films on ped faces; strongly acid; gradual smooth boundary.

IIB23t—32 to 36 inches; mottled yellowish brown (10YR 5/8) and gray (10YR 6/1) heavy clay loam; weak coarse subangular blocky structure; firm; medium acid; gradual smooth boundary.

IIB3t—36 to 60 inches; mottled brownish yellow (10YR 6/8) and gray (10YR 6/1) clay loam; massive; firm; medium acid.

The solum ranges from 42 to about 80 inches in thickness. The Ap horizon is very dark gray, very dark grayish brown, or very dark brown, and is 7 to 10 inches thick. The A2 horizon is yellowish brown or brown and is about 2 to 5 inches thick. The A horizon is dominantly loam, but the range includes silt loam. Unless limed, it is commonly strongly acid or medium acid in reaction. The upper part of the B horizon has patchy reddish brown or yellowish red clay films or coatings and grayish brown or gray mottles, and the lower part is strong brown or yellowish brown with common to many gray mottles.

Armstrong soils are mapped as a complex with Gara soils. They are near Ladoga, Pershing, and Weller soils. They have a higher clay content in the B horizon than Gara soils. Armstrong soils, unlike Ladoga, Pershing, and Weller soils, have a B horizon that formed in glacial till and have a higher sand content than those soils.

Bremer Series

The Bremer series consists of deep, poorly drained, nearly level soils on second bottom lands and terraces of small rivers, creeks, and streams. These soils formed in alluvial sediment eroded from loess, in glacial till, and in local residuum weathered from shale and limestone. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark gray silt loam about 8 inches thick. The subsoil is about 36 inches thick. In sequence from the top, the upper 10 inches of the subsoil is very dark gray, friable silty clay loam; the next 6 inches is very dark gray, firm heavy silty clay loam that has yellowish brown mottles; and the lower 20 inches is dark gray, firm heavy silty clay loam that has yellowish brown mottles. The underlying material, to a depth of 60 inches, is dark gray heavy silty clay loam that has strong brown mottles.

Permeability is slow, and available water capacity is high. A seasonal water table in winter and in spring is at a depth of 1 to 3 feet.

These soils have a high natural fertility. If they are drained, the main crops are corn, soybeans, and small grains. Undrained areas and other wet areas are used for summer and fall pasture.

Representative profile of Bremer silt loam in a hayfield about 120 feet west and 200 feet south of the center of sec. 30, T. 51 N., R. 14 W.:

Ap—0 to 8 inches; very dark gray (10YR 3/1) heavy silt loam; strong fine granular structure; friable; medium acid; abrupt smooth boundary.

B21t—8 to 18 inches; very dark gray (10YR 3/1) silty clay loam; strong fine angular blocky structure; friable; many fine dark concretions; medium acid; gradual smooth boundary.

B22t—18 to 24 inches; very dark gray (10YR 3/1) heavy silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; moderate medium angular blocky structure; firm, plastic; many fine dark concretions; slightly acid; gradual smooth boundary.

B23tg—24 to 44 inches; dark gray (10YR 4/1) heavy silty clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak coarse angular blocky structure; firm; plastic; many medium and fine dark concretions; slightly acid; gradual smooth boundary.

C—44 to 60 inches; dark gray (N 4/0) heavy silty clay loam; many medium distinct strong brown (7.5YR 5/6) mottles; weak coarse angular blocky structure; firm; plastic; slightly acid.

The solum ranges from 40 to 60 inches in thickness. The Ap horizon is very dark gray, black, or very dark grayish brown. It is dominantly silt loam, but the range includes silty clay loam. The A horizon ranges to as much as 18 inches in thickness in some profiles. The B horizon is very dark gray, dark gray, or gray with mottles of yellowish brown, strong brown, brown, or gray. It is silty clay loam or light silty clay.

Bremer soils are near Chariton and Fatima soils. They lack the grayish A2 horizon of Chariton soils and have a lower clay content in the B horizon. Bremer soils are more poorly drained and have a higher clay content in the B and C horizons than Fatima soils.

Br—Bremer silt loam. This nearly level soil is on low valley stream terraces, high second bottoms, and along the narrow upstream branches and drainageways that finger back into the uplands. Slopes are 0 to 2 percent. Areas range from 5 to 140 acres in size and are long and narrow to moderately wide and irregular in shape.

Included with this soil in mapping are small areas of poorly drained Chariton soils and areas of moderately well drained Fatima and Nodaway soils. In a few places small areas of moderately well drained Greenton soils are included.

Runoff is slow, and the hazard of erosion is slight. Removal of excess water is the main concern of management. Maintaining the naturally high content of organic matter is important to the tilth and fertility. The return of crop residue and use of green manure crops help to maintain the organic matter content. Diversions are needed in places to divert surface runoff water from adjoining uplands.

This soil is well suited to crops if excess water is removed or controlled. Small isolated or inaccessible areas and large wet areas are used for pasture. Good management is needed to prevent overgrazing and compaction of the surface soil by livestock during periods of extreme wetness and prolonged saturation. This soil has severe limitations for urban and recreational development. Suitability for wildlife habitat is fair. Capability unit IIw-2.

Carlow Series

The Carlow series consists of deep, level or nearly level, poorly drained soils on bottom lands of the major rivers and their larger tributaries. Some areas of these soils have slightly concave slopes or basinlike shapes. These soils formed in alluvial sediment eroded from upland soils that formed in loess and glacial till. The native vegetation is marsh grasses and some deciduous trees.

In a representative profile the surface layer is very dark gray silty clay about 9 inches thick. The subsoil is about 27 inches thick. The upper 15 inches of the subsoil is very dark grayish brown, firm silty clay and the lower 12 inches is dark grayish brown, firm silty clay that has strong brown mottles. The underlying material, to a depth of 60 inches, is dark grayish brown, firm clay that has reddish yellow mottles.

Permeability is very slow, and available water capacity is moderate. These soils have a seasonal high water table within one foot of the surface. They are subject to flooding or ponding for brief to long periods. The shrink-swell potential is high throughout this soil.

Cultivated areas of these soils are mainly in corn and soybeans. Some areas are used for pasture, and a few areas are wooded or have a cover of wetland shrubs and trees.

Representative profile of Carlow silty clay in a cultivated field about 2,200 feet north and 1,400 feet east of the southeast corner of sec. 31, T. 49 N., R. 15 W.:

Ap—0 to 9 inches; very dark gray (10YR 3/1) silty clay; moderate medium granular structure; firm, plastic when wet; neutral; abrupt smooth boundary.

B21g—9 to 24 inches, very dark grayish brown (2.5Y 3/2) silty clay; moderate coarse angular blocky structure; firm, plastic when wet; rust stains along root channels; medium acid; smooth gradual boundary.

B22g—24 to 36 inches; dark grayish brown (2.5Y 4/2) silty clay; many medium distinct strong brown (7.5YR 5/6 and 5/8) mottles; weak coarse angular blocky structure; firm; plastic when wet; medium acid; smooth diffused boundary.

Cg—36 to 60 inches; dark grayish brown (2.5Y 4/2) clay; many medium distinct reddish yellow (7.5YR 6/8) mottles; massive, firm; plastic; medium acid.

The solum ranges from 30 to 60 inches in thickness. The Ap horizon is very dark gray, black, or very dark grayish brown. The B horizon is dark grayish brown or dark gray. It has yellowish brown, strong brown, very dark grayish brown, brown, reddish yellow, grayish brown, or gray mottles. It is silty clay or clay, and the average content of clay is 48 to 55 percent. The C horizon is dark grayish brown, dark gray, or gray. It has yellowish brown, strong brown, reddish yellow, or yellowish red mottles. Texture is silty clay or clay.

These soils have a greater thickness of very dark gray and very dark grayish brown material than is given in the defined range for the series. This indicates deeper penetration of organic matter, but this difference does not alter the usefulness and behavior of these soils.

Carlow soils are near Fatima, Haynie, and Moniteau soils. They have a greater clay content throughout their solum and C horizon than these soils.

Ca—Carlow silty clay. This soil is in level to slightly concave and depressed areas of first bottom lands and isolated sloughs of the flood plains of the Missouri River and its major local tributaries. Areas range from long and narrow to rounded and irregular in shape and from 5 to about 280 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of well drained Haynie soils on small knolls and low moundlike ridges. Also included are a few areas of thin cuplike deposits of sandy overwash from recent flooding and breaks in the levees, and small areas of Leta soils. Small areas of moderately well drained Fatima and Nodaway soils are included on the flood plains of the smaller tributaries and creeks.

Runoff is very slow, and many areas are subject to extended periods of ponding (fig. 4). Damage caused by flooding, difficulty in removing excess water, and difficulty in maintaining tilth are the major limitations to use of this soil. Large flood control measures, land grading, and use of dikes and ditches are important flood prevention and water removal procedures where this soil is on Missouri River bottom land. Removal of excess water from this soil in areas on the smaller stream bottoms involves simpler systems of land grading and shallower collection ditches. Tilth is improved by plowing under crop residue, using cover crops, and using minimum tillage methods. Timing of plowing and planting operations with regard to optimum soil moisture conditions is extremely important. Fall plowing is beneficial in most cases.

This soil is suited to intensive crops if excess water is removed or controlled. This soil is not well suited to such perennial plants as alfalfa because of wetness and heaving problems. Many areas on the smaller streams are used for pasture. Good management is needed to prevent overgrazing and compaction of the surface soil by livestock during periods of wetness. This soil has a severe limitation for urban and recreational de-

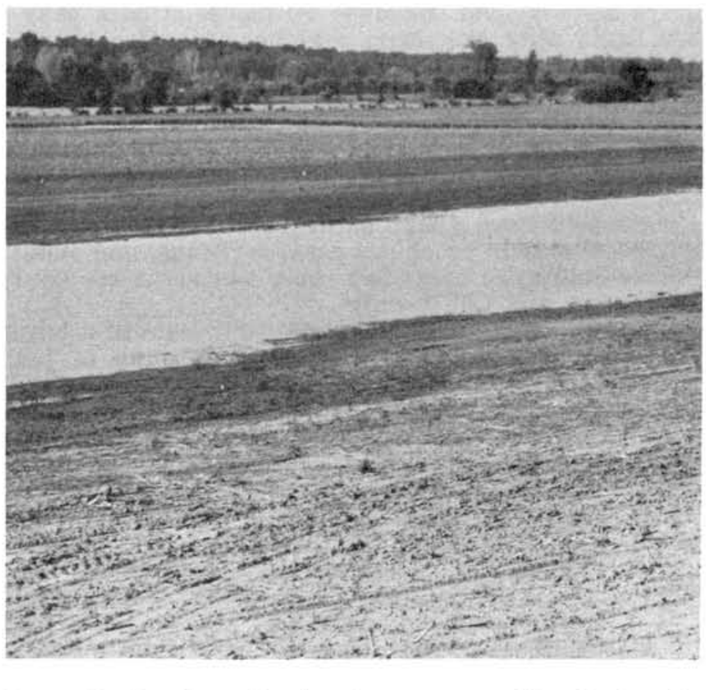


Figure 4.—**Ponding of local surface water runoff on Carlow silty clay soils of the Missouri River bottom lands.**

velopment. Suitability for wildlife habitat is poor to fair. Capability unit IIIw–14.

Chariton Series

The Chariton series consists of deep, nearly level, poorly drained soils on old terraces that adjoin the more recently formed terraces and bottom lands of the major rivers and streams. These soils formed in 40 to 60 inches of loess deposited on old alluvium. The native vegetation is marsh grasses and deciduous trees.

In a representative profile the surface layer is very dark grayish brown silt loam about 8 inches thick. The upper 21 inches of the subsoil is dark grayish brown, firm silty clay that has yellowish brown mottles. The lower 22 inches is gray, firm silty clay loam that has yellowish brown and light brownish gray mottles.

Permeability is slow, and available water capacity is high. The shrink-swell potential of the subsoil is high. These soils have a high water table in winter and spring.

Most areas of these soils are cultivated. The main crops are corn, soybeans, and small grains. Some areas are in legumes and grasses or are used for hay or pasture.

Representative profile of Chariton silt loam in a pasture about 1,200 feet east and 700 feet south of the northwest corner of sec. 19, T. 50 N., R. 14 W.:

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

A2—8 to 17 inches; gray (10YR 5/1) silt loam; weak fine granular structure; few fine dark concretions; friable; medium acid; clear smooth boundary.

B1—17 to 20 inches; dark grayish brown (10YR 4/2) silty clay loam; common fine yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; firm; strongly acid; gradual smooth boundary.

B21t—20 to 38 inches; dark grayish brown (10YR 4/2) silty clay; many medium distinct yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; firm, plastic; strongly acid; gradual smooth boundary.

B22t—38 to 44 inches; mixed gray (10YR 5/1), yellowish brown (10YR 5/6, 5/7, 5/8) and light brownish gray (2.5Y 6/2) heavy silty clay loam; weak coarse subangular blocky structure; firm, plastic; strongly acid; gradual wavy boundary.

B3—44 to 60 inches; mottled gray (10YR 5/1), yellowish brown (10YR 5/6, 5/7, 5/8), and light brownish gray (2.5Y 6/2) silty clay loam; very weak fine subangular blocky structure; firm; slightly acid.

The solum ranges from 40 to about 60 inches in thickness. The Ap horizon is very dark gray, very dark grayish brown, or black. The A2 horizon is gray, grayish brown, or dark grayish brown. The B1 horizon is lacking in some profiles. The B2t horizon is dark grayish brown or grayish brown. The upper 20 inches of the B2t horizon averages between 48 and 60 percent clay. Some profiles have a C horizon that is mottled gray and yellowish brown very fine sandy clay loam, clay loam, or heavy sandy loam. This horizon commonly is below a depth of 45 inches.

Chariton soils are near Bremer, Fatima, and Freeburg soils. They have a higher clay content in the upper 20 inches of the B2t horizon than Bremer soils. Chariton soils have a higher clay content throughout the solum and are more poorly drained than Fatima soils. Chariton soils have a darker Ap horizon, contain more clay in the B2t horizon, and are slightly wetter than Freeburg soils.

Ch—Chariton silt loam. This nearly level soil is on high second bottom terraces along the secondary streams and tributaries of the Missouri River. Areas are typically longer than they are wide and range from about 8 to 120 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of poorly drained Carlow and Bremer soils. Also included are a few small areas of somewhat poorly drained Freeburg soils. In a few areas short, gentle to moderate slope conditions are included along the edges bordering the lower first bottom soils.

Runoff is slow, and the hazard of erosion is slight. Removal of excess water, improvement of fertility, and the maintenance of tilth are the main concerns when managing this soil. Plowing under of crop residue, use of cover crops, and minimum tillage help maintain the organic matter content and improve tilth. Diversion terraces are needed in places to divert surface runoff from adjoining uplands.

This soil is well suited to crops where excess water is removed or controlled. Small isolated or inaccessible areas and large wet areas are used for pasture. Good management is needed to prevent overgrazing and compaction of the surface soil by livestock during periods of extended wetness. This soil has severe limitations for urban and recreational development. Suitability for wildlife habitat is fair. Capability unit IIw–2.

Edina Series

The Edina series consists of deep, level to nearly level, poorly drained soils on broad loess covered glacial till plains. These soils formed in loess about 7 to 10 feet thick. They are underlain by dense, highly weathered, old glacial till. The native vegetation is prairie grasses.

In a representative profile the surface layer is very dark gray silt loam about 9 inches thick. The subsurface layer is gray silt loam about 7 inches thick. The upper 7 inches of the subsoil is very dark gray, firm silty clay that has yellow mottles; the next 13 inches is dark grayish brown, firm silty clay that has dark yellowish brown mottles; and the lower part, to a depth of 60 inches, is firm silty clay loam that has grayish brown and light olive brown mottles.

Permeability is very slow, and the available water capacity is high. A seasonal high water table is present in winter and spring.

Most areas of Edina soils are cultivated. The main crops are corn, soybeans, small grains, and hay. A few small areas are used for pasture.

Representative profile of Edina silt loam in a cultivated field about 2,200 feet west and 1,600 feet north of the southeast corner of sec. 10, T. 52 N., R. 16 W.:

Ap—0 to 9 inches; very dark gray (10YR 3/1) silt loam; strong medium granular structure; friable; neutral; abrupt smooth boundary.

A2—9 to 16 inches; gray (10YR 5/1) silt loam; moderate fine granular structure; many small dark concretions; friable; medium acid; abrupt smooth boundary.

B1—16 to 18 inches; very dark gray (10YR 3/1) silty clay loam; strong very fine subangular blocky structure; firm, slightly plastic; many small dark concretions; medium acid; clear smooth boundary.

B21t—18 to 23 inches; very dark gray (10YR 3/1) silty clay; few fine distinct yellow (10YR 7/8) mottles; moderate coarse blocky structure; firm, plastic; many small dark concretions; medium acid; gradual smooth boundary.

B22t—23 to 36 inches; dark grayish brown (2.5Y 4/2) silty clay; many medium distinct dark yellowish brown (10YR 4/4) mottles; weak coarse blocky structure; firm; many fine and medium dark concretions; slightly acid; gradual smooth boundary.

B3—36 to 60 inches; mottled grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) silty clay loam; weak coarse blocky structure; firm, slightly plastic; many fine and medium dark concretions; slightly acid.

The solum ranges from about 45 to 60 inches or more in thickness. The Ap horizon is very dark gray, very dark grayish brown, or black. The A2 horizon is gray or dark gray. The B1 horizon is not in some profiles. The B21t horizon is very dark gray or black and commonly has dark gray, yellowish brown, brown, or yellow mottles. The upper 20 inches of the B21t horizon averages between 45 and 55 percent clay.

Edina soils are near Grundy, Greenton, and Sharpsburg soils. They are more poorly drained and have a grayer subsoil than these soils. Edina soils are on wide flats of ridgetops above the Grundy soils that are on the side slopes and below the Sharpsburg soils that are on narrow convex parts and pointed ends of the ridges. Edina soils lack the residuum weathered from shale underlying the Greenton soils at a depth of about 42 inches.

Ed—Edina silt loam. This level to nearly level soil is on the flat parts of wide ridgetops. The areas are irregularly shaped and range from about 2 to 80 acres in size. Slopes are 0 to 2 percent. Included in mapping are a few small areas of Grundy soils.

Runoff is very slow, and the hazard of erosion is slight. Removal of excess water is the main concern in the management of this soil. Maintaining high organic content and improving the fertility are important to the tilth and productivity of this soil. Plowing under the crop residue and using cover crops help to maintain the organic matter content. Excess surface water can be effectively removed in most places by grading and providing shallow collection ditches.

This soil is well suited to crops if the excess water is removed. Some areas are in pasture, but good management is needed in these areas to prevent overgrazing and compaction of the surface soil by livestock during periods of extended wetness. The soil has severe limitations for urban and recreational development, but suitability as habitat for wildlife is fair to good. Capability unit IIw-2.

Fatima Series

The Fatima series consists of deep, level to nearly level, moderately well drained soils on narrow bottom lands of small upland streams and the wider bottoms of the larger creeks that eventually drain into the Missouri River. These soils formed in silty alluvial sediment derived from the loess and glacial till soils of the surrounding uplands. The native vegetation is mixed hardwoods.

In a representative profile the surface layer is very dark grayish brown silt loam about 10 inches thick. The upper 10 inches of the subsoil is dark brown, friable silt loam that has dark gray mottles, and the lower 22 inches is dark grayish brown, friable silt loam that has gray mottles. The underlying material, to a depth of 60 inches, is dark grayish brown, friable silt loam that has yellowish brown mottles.

Permeability is moderate, and available water capacity is very high. These soils are subject to flooding late in winter and early in spring.

These soils have a high natural fertility, and cultivated areas are planted mainly to corn and soybeans. Small or inaccessible areas are used for pasture or remain wooded.

Representative profile of Fatima silt loam in a cultivated field about 800 feet east and 180 feet north of the southwest corner of sec. 30, T. 51 N., R. 14 W.:

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

B1—10 to 20 inches; dark brown (10YR 4/3) silt loam; common fine faint dark gray (10YR 4/1) mottles; weak medium angular blocky structure; friable; slightly acid; gradual smooth boundary.

B2—20 to 42 inches; dark grayish brown (10YR 4/2) silt loam; common fine and medium distinct gray (10YR 5/1) mottles; weak medium subangular blocky structure; friable; slightly acid; diffuse smooth boundary.

C—42 to 60 inches; dark grayish brown (10YR 4/2) silt loam; few fine faint dark gray (10YR 4/1) and distinct yellowish brown (10YR 5/4) mottles; massive; friable; slightly acid.

The solum ranges from 40 to about 60 inches in thickness. The A horizon is very dark grayish brown, very dark gray, or black, and it ranges from 10 to 15 inches in thickness. It is slightly acid or neutral in reaction. The B1 horizon is dark brown and generally has dark gray, gray, or grayish brown mottles, but in some profiles it is dark grayish brown and is without mottles. It is slightly acid or neutral. The B2 and C horizons, in some places, contain thin strata of grayish brown, dark gray, very dark gray, or black silt loam or light silty clay loam. They are slightly acid or neutral.

Fatima soils are near Bremer, Carlow, Freeburg, Moniteau and Nodaway soils. They have a lower clay content in the subsoil and are not so wet as Bremer and Carlow soils. Fatima soils have a thicker and darker surface layer, less clay in the subsoil, and are not so wet as the Freeburg and Moniteau soils. Fatima soils have a thicker dark surface layer than the Nodaway soils. They also lack the stratification below the plow layer that is characteristic of the Nodaway soils.

Fa—Fatima silt loam. This level to nearly level soil is is on first bottoms of the small streams and creeks. The areas are typically longer than they are wide and border the active stream channel in the narrow upper parts of the smaller streams, but they range to irregularly shaped areas that set back from the active channels of the larger creeks. Areas of this soil range from about 5 to 100 acres in size. Slopes are 0 to 2 percent.

Runoff is slow, and the hazard of erosion is slight. Flooding is the major limitation in the use and management of this soil. Very few areas can be protected from flooding (fig. 5).

This soil is well suited to intensive crops, but losses because of flooding are a constant problem. Many frequently flooded areas and most of the small, narrow, or inaccessible areas are pastures. The soil has a severe limitation for urban development and a severe to moderate limitation for recreational use. Suitability as habitat for openland and woodland wildlife is good. It has a poor suitability for wetland wildlife. This soil has the potential to produce high quality walnut timber in a relatively short time. Capability unit IIw–1.

Figure 5.—Fatima soil area on the bottom lands of Bonne Femme Creek. Long, graded dead furrows act as drainageways for removal of short lasting flood waters.

Freeburg Series

The Freeburg series consists of deep, somewhat poorly drained, nearly level soils on low terraces on the bottom lands of small upland streams and major creeks. These soils formed in silty alluvial sediment derived from the nearby uplands. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark grayish brown silt loam about 7 inches thick. The subsurface layer is brown silt loam about 5 inches thick. The upper part of the subsoil is mottled, yellowish brown, dark grayish brown, and dark yellowish brown, friable silty clay loam. The middle part is mottled, brown, yellowish brown, and light brownish gray, firm clay loam. The lower part, to a depth of about 60 inches, is gray, friable, light silty clay loam that has yellowish brown mottles.

Permeability is moderately slow, and available water capacity is high. A seasonal high water table is present in the winter and spring when these soils are subject to occasional flooding.

These soils have a medium natural fertility, and where cultivated they are planted mostly to corn, soybeans, small grains, and some hay. Small and inaccessible areas are in pasture or remain wooded.

Representative profile of Freeburg silt loam in a cultivated field about 1,200 feet south and 1,700 feet east of the northwest corner of sec. 35, T. 52 N., R. 15 W.:

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam; strong fine granular structure; very friable; neutral; abrupt smooth boundary.

A2—7 to 12 inches; brown (10YR 5/3) silt loam; moderate fine granular structure; very friable; neutral; clear smooth boundary.

B21t—12 to 19 inches; mottled yellowish brown (10YR 5/4), dark grayish brown (10YR 4/2), and dark yellowish brown (10YR 4/4) silty clay loam; moderate medium subangular blocky structure; friable; thin patchy clay films on faces of peds; few fine dark concretions; medium acid; gradual wavy boundary.

B22t—19 to 30 inches; mottled brown (10YR 5/3) and yellowish brown (10YR 5/6) clay loam; faces of peds light brownish gray (10YR 6/2); strong medium and coarse angular blocky structure; firm, slightly plastic wet; thin continuous clay films on ped surfaces; few fine dark concretions; very strongly acid; gradual smooth boundary.

B31—30 to 48 inches; gray (10YR 5/1) light silty clay loam; many medium distinct yellowish brown (10YR 5/4) mottles; ture; friable; strongly acid; gradual moderate coarse angular blocky structure; friable; strongly acid; gradual smooth boundary.

B32—48 to 60 inches; gray (10YR 5/1) light silty clay loam; many medium yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; friable; common fine dark concretions of iron and manganese oxides; strongly acid.

The solum ranges from 33 to 60 inches or more in thickness. The Ap horizon is dark grayish brown or dark brown. The A2 horizon is grayish brown, light grayish brown, pale brown, or brown. The A horizon is dominantly silt loam, but the range includes loam. This horizon is slightly acid or neutral in reaction. The B2t horizon is mainly a mottled mixture of dark grayish brown, yellowish brown, or light brownish gray. It is silty clay loam or clay loam and strongly acid to very strongly acid in the lower part. The B3 horizon is gray or dark gray with yellowish brown mottles. It is silty clay loam or clay loam and is typically strongly acid.

Freeburg soils are near Carlow, Chariton, Fatima, Moniteau and Nodaway soils. They are not so wet as the Carlow, Chariton, and Moniteau soils. They have a lower clay content in the subsoil than the Carlow or Chariton soils. Freeburg soils are more poorly drained and have a higher clay content in the subsoil than the Fatima and Nodaway soils.

Fr—Freeburg silt loam, 0 to 3 percent slopes. This soil is on terraces and second bottoms of small streams and creeks. The areas are typically long and narrow but range to irregular or nearly round and are 2 to about 120 acres in size.

Included with this soil in mapping are a few small areas of poorly drained Moniteau and Bremer soils. Also included are small areas of moderately well drained Fatima and Nodaway soils. Some short areas of moderately sloping soils that border the lower first bottom soils are included in the larger areas of this soil.

Runoff is slow, and the hazard of erosion is slight. Flooding, removing excess water, and improving the organic matter content and fertility are the main management concerns. Grading and providing shallow drainage ditches help in the removal of excess water. Using minimum tillage practices, plowing under crop residue, and using cover crops help to build up the organic matter content.

This soil is well suited to crops if excess water is removed and flooding is infrequent or occurs earlier than planting time. Most of the smaller or inaccessible areas are in pasture, but good management is needed to prevent overgrazing and compaction of the surface soil by livestock during periods of extended wetness. The soil has severe limitations for urban development, but it has some limited potential for recreational use. Suitability for wildlife habitat is fair to good. Capability unit IIw-1.

Gara Series

The Gara series consists of deep, moderately sloping to strongly sloping, moderately well drained soils on uplands. These soils formed in loamy glacial till. The native vegetation is trees and prairie grasses.

In a representative profile the surface layer is very dark brown and dark brown loam about 8 inches thick. The subsurface layer is dark brown loam about 3 inches thick. The subsoil is firm clay loam about 31 inches thick. The upper part is dark yellowish brown and dark brown and has yellowish red mottles. The lower part is yellowish brown and has light brownish gray and gray mottles. It is underlain by mottled, yellowish brown and grayish brown, firm clay loam at a depth of about 42 inches.

Permeability is moderately slow, and available water capacity is high. The shrink-swell potential of the subsoil is moderate.

Most areas of these soils are used for pasture or hay. Some areas are cultivated and planted mainly to corn, sorghum, and small grains. Uneroded areas have medium natural fertility, but eroded areas are low in fertility. Wooded areas are mostly second growth oak and hickory.

Representative profile of Gara loam from an area of Gara and Armstrong loams, 5 to 9 percent slopes, in an idle brushy area about 2,800 feet north and 40 feet west of the southeast corner of sec. 5, T. 50 N., R. 15 W.:

A11—0 to 2 inches; very dark brown (10YR 2/2) loam; moderate fine granular structure; friable; neutral; abrupt smooth boundary.

A12—2 to 8 inches; dark brown (10YR 3/3) loam; moderate fine granular structure; friable; few pebbles and stones; medium acid; clear irregular boundary.

A2—8 to 11 inches; dark brown (10YR 4/3) loam; weak fine granular structure; friable; few pebbles and stones; medium acid; clear smooth boundary.

B21t—11 to 15 inches; dark yellowish brown (10YR 4/4) light clay loam; moderate very fine subangular blocky structure; firm; discontinuous clay films on faces of peds; few pebbles and stones; strongly acid; clear smooth boundary.

B22t—15 to 24 inches; dark brown (10YR 4/3) heavy clay loam; common fine distinct yellowish red (5YR 4/6) mottles; moderate fine blocky structure; firm; thin discontinuous dark yellowish brown (10YR 4/4) clay films on faces of peds; few pebbles and stones; strongly acid; gradual smooth boundary.

B23t—24 to 35 inches; yellowish brown (10YR 5/4) heavy clay loam; many medium distinct light brownish gray (10YR 6/2) and common medium distinct yellowish brown (10YR 5/8) mottles; weak medium blocky structure; firm; few pebbles and stones; strongly acid; gradual smooth boundary.

B3—35 to 42 inches; mottled yellowish brown (10YR 5/8) and gray (10YR 6/1) clay loam; weak coarse blocky structure; firm; few pebbles and stones; strongly acid; gradual smooth boundary.

C—42 to 54 inches; mottled yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) light clay loam; massive; some vertical cleavage; firm; few pebbles and stones; neutral.

The solum ranges from about 40 to 60 inches or more in thickness and contains few to common pebbles and a few cobbles and stones. Where plowed, the surface layer is very dark grayish brown or very dark gray. The A2 horizon is either dark brown to brown when moist and pale brown, or it is dark grayish brown when dry. The A horizon ranges from medium acid to neutral in reaction depending on local practices of liming. The B2t horizon is dark yellowish brown or dark brown. In places it lacks the yellowish red mottles. Gray, light brownish gray, or grayish brown mottles occur only in the lowest parts of the B2t horizon. In the B2t horizon, texture ranges from light to heavy clay loam, and reaction ranges from strongly acid to slightly acid. The B3 and C horizons are yellowish brown, dark yellowish brown, gray, grayish brown, or light brownish gray. Reaction in these horizons ranges from medium acid to neutral.

These soils are slightly finer textured and have a thinner solum than is given in the defined range for the series, but these differences do not alter their usefulness and behavior.

Gara soils are mapped as a complex with Armstrong soils, and they are near Ladoga, Pershing, and Weller soils. They have a lower clay content in the B horizon than the Armstrong soils. Gara soils formed in glacial till and have a higher content of sand, pebbles, cobbles, and stones throughout than the Ladoga, Pershing, and Weller soils.

GaC—Gara and Armstrong loams, 5 to 9 percent slopes. These soils are on the tops and sides of ridges in the uplands. The areas are irregularly shaped and range from about 5 to 200 acres in size. These soils generally occur together. Most mapped areas contain both soils, but some areas are entirely one soil or the other.

The Gara soil commonly makes up about 60 percent of the total acreage of this mapping unit, and the Armstrong soil makes up about 40 percent. The Gara soil occupies the middle and lower parts of side slopes. The Armstrong soil is on narrow, convex ridgetops and upper parts of side slopes. In some areas only one soil is present. These soils have the profiles described as representative of their series. In many places these soils are only on the side slopes, and the adjoining ridgetop is occupied by completely different kinds of soils.

Included with these soils in mapping are small areas of moderately well drained Weller or Winfield soils. Also included are small areas where the surface layer has been eroded away and the subsoil is exposed and a few areas where slopes are more than 9 percent. Where Gara and Armstrong soils are on sides of ridges that have broad tops, a few small areas of somewhat poorly drained Grundy or Pershing soils are included.

Runoff is medium, and the hazard of erosion is one of the main concerns of management. Maintenance and improvement of organic matter content and fertility are important practices when using these areas for farming. Conservation crop sequences, contour farming, terraces, minimum tillage, cover crops, and stripcropping are effective measures in helping to control erosion. Returning all crop residue to the soil and use of green manure crops help to maintain the tilth and the organic matter content.

These soils are suited to crops if erosion is controlled. Many areas are used for pasture, but good management is needed to establish high quality forage and prevent overgrazing. The soils have slight to moderate limitations for most urban and recreational development. Suitability as habitat for openland and woodland wildlife is good. Capability unit IIIe–1.

GaD—Gara and Armstrong loams, 9 to 14 percent slopes. These soils are on the sides and narrow tops of ridges in the uplands. The areas are typically longer than they are wide and are irregularly shaped. They range from about 8 to 160 acres in size. These soils generally occur together. Most mapped areas contain both soils, but some areas are entirely one soil or the other.

The Gara soil commonly makes up about 80 percent of the total acreage of this mapping unit, and the Armstrong soil makes up about 20 percent. The Gara soil is on the middle and lower parts of side slopes, and the Armstrong soil occupies the upper parts of side slopes.

Included with these soils in mapping are small areas where slopes are steeper than 14 percent and a few areas where slopes are less than 9 percent. Some areas have small spots where the surface layer has eroded away and the subsoil is exposed. Most of the eroded spots are on the Armstrong soils or occur in gullies in the drainageways of the Gara soils.

Runoff is rapid, and the hazard of erosion is a major concern in using these areas for farming. Slope conditions in most areas are too steep and irregular for contour farming or terraces. Stripcropping and cropping sequences that include small grains and hay are practical measures to control erosion. The return of crop residue and use of green manure crops help to maintain tilth and organic matter content.

These soils are suitable for limited cropping. Many areas are used for hay and pasture, but good management is needed to establish high quality forage and prevent overgrazing. The soils have moderate to severe limitations for most urban uses and recreational development. Suitability for openland and woodland wildlife habitat is poor to good. Capability unit IVe–1.

GcC3—Gara and Armstrong clay loams, 5 to 9 percent slopes, severely eroded. These soils are on the tops and sides of ridges in the uplands. The areas are irregularly shaped and range from about 3 to 160 acres in size. These soils generally occur together. Most mapped areas contain both soils, but some areas are entirely one soil or the other.

The Gara soil commonly makes up about 60 percent of the total average of this mapping area, and the Armstrong soil makes up about 40 percent. The Gara soil occupies the middle and lower parts of the side slopes, and the Armstrong soil occupies the narrow convex ridgetops and upper parts of the side slopes. These soils once had profiles similar to those described as representative of their series. Because of erosion, however, they lack the loam surface layer, and the plow layer is mainly in the clay loam upper part of the former subsoil. In many places these soils are only on side slopes, and the adjoining ridgetop is occupied by a completely different kind of soil.

Included with these soils in mapping are small areas where part or all of the original loam surface layer remains. Also included are a few areas where slopes are more than 9 percent.

Runoff is rapid, and the hazard of further erosion is a major concern when managing these soils. Because of poor tilth, lack of organic matter, and the high clay content of the plow layer, it is difficult to prepare a good seedbed. Extremely good management is needed to effectively crop these soils. They are better suited to hay and pasture than to other uses. These soils have moderate limitations for most urban uses and moderate to severe limitations for recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IVe–4.

Greenton Series

The Greenton series consists of deep, moderately well drained, and gently sloping to strongly sloping soils on uplands. These soils formed in thin to moderately thick loess deposits and the underlying residuum weathered from clay shale and thinly bedded limestone. The native vegetation is tall prairie grass.

In a representative profile the surface layer is mainly very dark grayish brown silt loam about 12 inches thick. The upper part of the subsoil formed in loess and is about 8 inches thick. It is dark brown silty clay loam and dark brown silty clay and has light brownish gray and strong brown mottles. The lower part of the subsoil formed in residuum weathered from shale and is about 22 inches thick. It is dark brown silty clay loam and dark brown silty clay and has light brownish gray and strong brown mottles. The lower part of the subsoil formed in residuum weathered from shale and is about 22 inches thick. It is mottled, dark yellowish brown, light brownish gray, and yellowish brown silty clay and clay. Underlying the subsoil, at a depth of about 42 inches, is weathered, soft, silty and clayey shale.

Permeability is slow, and available water capacity is moderate. The shrink-swell potential of the subsoil is high.

Most areas of these soils are cultivated, and the main crops are corn, soybeans, small grains, and hay. Areas of steeper soils are either planted to grass and legume hay or are in pasture.

Representative profile of Greenton silt loam, 5 to 9 percent slopes, in a pasture about 3,200 feet west and 2,500 feet south of the northeast corner of sec. 25, T. 52 N., R. 16 W.:

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam; strong medium granular structure; friable; medium acid; clear smooth boundary.

A12—9 to 12 inches; very dark gray (10YR 3/1) silt loam; strong medium granular structure; friable; medium acid; abrupt smooth boundary.

B21t—12 to 14 inches; dark brown (7.5YR 3/2) silty clay loam; strong fine subangular blocky structure; firm; medium acid; clear smooth boundary.

B22t—14 to 20 inches; dark brown (7.5YR 4/3) silty clay; many fine distinct light brownish gray (10YR 6/2) and strong brown (7.5YR 5/6) mottles; strong fine slightly acid; abrupt smooth boundary.

IIB23t—20 to 28 inches; mottled dark yellowish brown (10YR 4/4) and light brownish gray (10YR 6/2) silty clay; moderate medium subangular blocky structure; firm; few pieces of partly weathered silty shale; slightly acid; clear smooth boundary.

IIB3—28 to 42 inches; mottled light brownish gray (2.5Y 6/2) and yellowish brown (10YR 5/8) clay; moderate medium subangular blocky structure; firm; many pieces of partly weathered silty shale; neutral; clear irregular boundary.

C—42 to 60 inches; olive brown (2.5Y 4/4) weathered soft silty and clayey shale; many small slightly weathered pieces of limestone.

The solum ranges from about 38 to 50 inches in thickness. Depth to weathered shale ranges from 40 to about 70 inches. The A horizon is very dark grayish brown, very dark brown, very dark gray, or black. It is 10 to 16 inches thick. This horizon is medium acid or slightly acid in reaction. The B2t horizon is silty clay loam or silty clay. It is slightly acid or neutral and is 2 to about 20 percent small, weathered, shale and limestone fragments. The C horizon in some profiles is thick, clayey, massive residuum that is mildly alkaline.

Greenton soils are near Grundy, Sharpsburg, and Edina soils. They have a thin loess mantle underlain by clayey residuum weathered from shale as compared to the Grundy soils that are underlain, at a depth of 40 inches or more, by glacial till. The Sharpsburg and Edina soils, on the other hand, formed in loess deposits more than 6 feet thick.

GnB—Greenton silt loam, 2 to 5 percent slopes. This soil is on the upper parts of side slopes just below the outer edges of broad ridgetops or on narrow slightly lower ridgetops and pointlike ends of ridges. The areas are typically longer than they are wide, but in places they are small and irregularly shaped. They range from about 3 to 30 acres in size.

Included with this soil in mapping are some small areas of somewhat poorly drained Grundy soils and moderately well drained Sharpsburg soils. These thicker loess derived soils generally are on the higher, gently sloping, broad ridgetops adjoining the slightly lower Greenton soils. In a few places slopes are slightly more than 5 percent.

Runoff is medium, and the hazard of erosion is moderate. Controlling erosion, improving fertility, and maintaining tilth are the main concerns of management. The use of properly designed terrace systems, grassed waterways, contour farming, and conservation cropping sequences help to protect against erosion. Plowing under of crop residue and minimum tillage practices help to improve and maintain tilth and the organic matter content.

This soil is well suited to crops where erosion is controlled. Some areas are used for hay or pasture, and prevention of overgrazing is the main concern of management. The soil has severe limitations for urban uses and slight to moderate limitations for developing various types of recreational facilities. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–5.

GnC—Greenton silt loam, 5 to 9 percent slopes. This soil is on the sides of broad topped upland ridges. It commonly occupies the middle and lower positions of long side slopes, or it immediately joins the flatter soils of the ridgetops, occupying the entire slope from the crest down to the drainageway. The areas are typically longer than they are wide and are irregularly shaped. They range from 3 to about 130 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas where slopes are either more than 9 percent or less than 5 percent. The steeper slopes also have small areas where the surface layer is eroded and the fine textured subsoil is exposed. In a few places moderately well drained Gara and Armstrong soils are included. Some small areas of somewhat poorly drained Grundy silt loam soils are also included.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are control of erosion, improvement of fertility, and maintenance of tilth. Many areas of this soil have slope conditions that are too irregular and complex to establish a complete system of terraces for erosion control purposes, but most areas can be helped by properly placed diversion-type terraces, waterways, minimum tillage, modified stripcropping, and contour farming. Plowing under of crop residue and use of green manure crops help maintain the tilth of these areas.

This soil is suited to crops if erosion is controlled. Many areas are used for hay and pasture. Good management is needed to establish high quality forage and prevent overgrazing. The soil has severe limitations for urban uses and slight to severe limitations for developing various types of recreational facilities. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–5.

GnD—Greenton silt loam, 9 to 14 percent slopes. This soil is on side slopes adjacent to narrow fingerlike parts of broad upland ridgetops and on foot slopes next to deeply entrenched drainageways and bottoms of small secondary streams. The areas are long, narrow, and irregularly shaped. They range from about 5 to 30 acres in size.

Included with this soil in mapping are a few areas where slopes are more than 14 percent and some areas where slopes are less than 9 percent. Some small areas of moderately well drained Ladoga and Sharpsburg soils are included. These soils typically are on the higher parts of the side slopes along the crests of ridges. Small areas of the moderately well drained Gara and Armstrong soils are also included both above and below areas of this soil.

Runoff is rapid, and the hazard of erosion is severe. Controlling erosion is a major concern of management. Maintenance and improvement of fertility and tilth are also important and are made more difficult by erosion. Most areas are too steep and too irregularly shaped for such erosion control practices as terracing and contour farming. Some modified systems of stripcropping and conservation crop sequences provide good methods of erosion control when these soils are cultivated. Good management is needed to establish high quality forage crops for hay or pasture and to prevent overgrazing. Plowing down crop residue helps to improve and maintain tilth and fertility.

This soil is suited to hay or pasture, but these areas can be successfully cultivated if small grains and hay are rotated in the cropping system. It has severe limitations for urban uses and slight to severe limitations for developing various types of recreational facilities. Suitability as habitat for open land and woodland wildlife is good. Capability unit IVe–5.

Grundy Series

The Grundy series consists of deep, somewhat poorly drained, gently sloping to moderately sloping soils on uplands. These soils formed in moderately thick deposits of loess on old glacial till plains. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark brown silt loam about 18 inches thick. The upper 6 inches of the subsoil is very dark gray, firm silty clay loam. The middle 18 inches is dark yellowish brown and light brownish gray, firm silty clay that has yellowish brown mottles. The lower 18 inches is mottled, grayish brown and yellowish brown, firm silty clay loam.

Permeability is slow, and available water capacity is high. A seasonal high water table occurs late in winter and in spring. The shrink-swell potential of the subsoil is high.

These soils have a high natural fertility, and cropped areas are planted to corn, soybeans, small grains, and hay. Small acreages are in pasture or are used for feedlots.

Representative profile of Grundy silt loam, 2 to 5 percent slopes, in pasture about 400 feet east and 100 feet north of the center of sec. 9, T. 52 N., R. 16 W.:

Ap—0 to 11 inches; very dark brown (10YR 2/2) silt loam; moderate medium granular structure; friable; medium acid; gradual smooth boundary.

A12—11 to 18 inches; very dark brown (10YR 2/2) silty clay loam; moderate fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B1—18 to 24 inches; very dark gray (10YR 3/1) silty clay loam; medium very fine subangular structure; firm; small dark concretions; strongly acid; gradual smooth boundary.

B21t—24 to 34 inches; dark grayish brown (10YR 4/2) silty clay; many fine distinct yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; firm; strongly acid; gradual smooth boundary.

B22t—34 to 42 inches; light brownish gray (2.5Y 6/2) silty clay; many fine distinct yellowish brown (10YR 5/6) mottles; moderate medium and fine angular blocky structure; firm; thin patchy dark grayish brown (10YR 4/2) clay films on ped faces; slightly acid; gradual smooth boundary.

B3—42 to 60 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) silty clay loam; weak medium subangular blocky structure; firm; slightly plastic; many medium and fine soft dark granules and stains of iron and manganese oxides; slightly acid.

The solum ranges from about 45 to 60 inches or more in thickness. The A horizon is very dark brown, very dark grayish brown, or very dark gray. It ranges from strongly acid to slightly acid in reaction, depending on local practices of liming. The B1 horizon is very dark gray or very dark grayish brown and strongly acid or medium acid. The B21t horizon is dark grayish brown or dark brown and has light brownish gray, gray, brownish gray, and yellowish brown mottles. The B22t horizon is light brownish gray or grayish brown and has yellowish brown, dark yellowish brown, or dark grayish brown mottles. It is silty clay or heavy silty clay loam. The B2t horizon ranges from strongly acid to slightly acid. The B3 horizon is mainly mottled grayish brown and yellowish brown, but some profiles have gray and dark yellowish brown and olive gray mottles in the lowest parts. Reaction ranges from medium acid to neutral in the B3 horizon.

Grundy soils are near Edina, Sharpsburg, and Greenton soils. They are not so wet as Edina soils, and they lack the dominantly gray subsoil of Edina soils. Grundy soils are wetter than Sharpsburg soils, and gray mottles are closer to the surface in Grundy soils than in Sharpsburg soils. Grundy soils lack the clayey residuum weathered from shale in the lower part of the solum that is characteristic of Greenton soils.

GrB—Grundy silt loam, 2 to 5 percent slopes. This soil is on broad, gently sloping to slightly undulating ridgetops of the higher parts of the uplands (fig. 6). The areas are large and irregularly shaped and range from about 3 to more than 1,000 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are many small areas of poorly drained Edina silt loam that occupy slight depressions and concave upper parts of drainageways. Also included are a few areas of moderately well drained Sharpsburg silt loam on small convex knolls or mounds and sharply sloping shoulders at the outer edges of ridgetops. In a few places small areas of moderately well drained Greenton silt loam are included, and in some small areas, slopes are slightly more than 5 percent.

Runoff is medium, and the hazard of erosion is slight to moderate. The main concerns of management are controlling erosion and maintaining tilth and fertility. Erosion can be controlled by properly designed and installed terrace systems, grassed waterways, contour farming, stripcropping, cropping sequences, or combinations of these soil conservation measures. Minimum

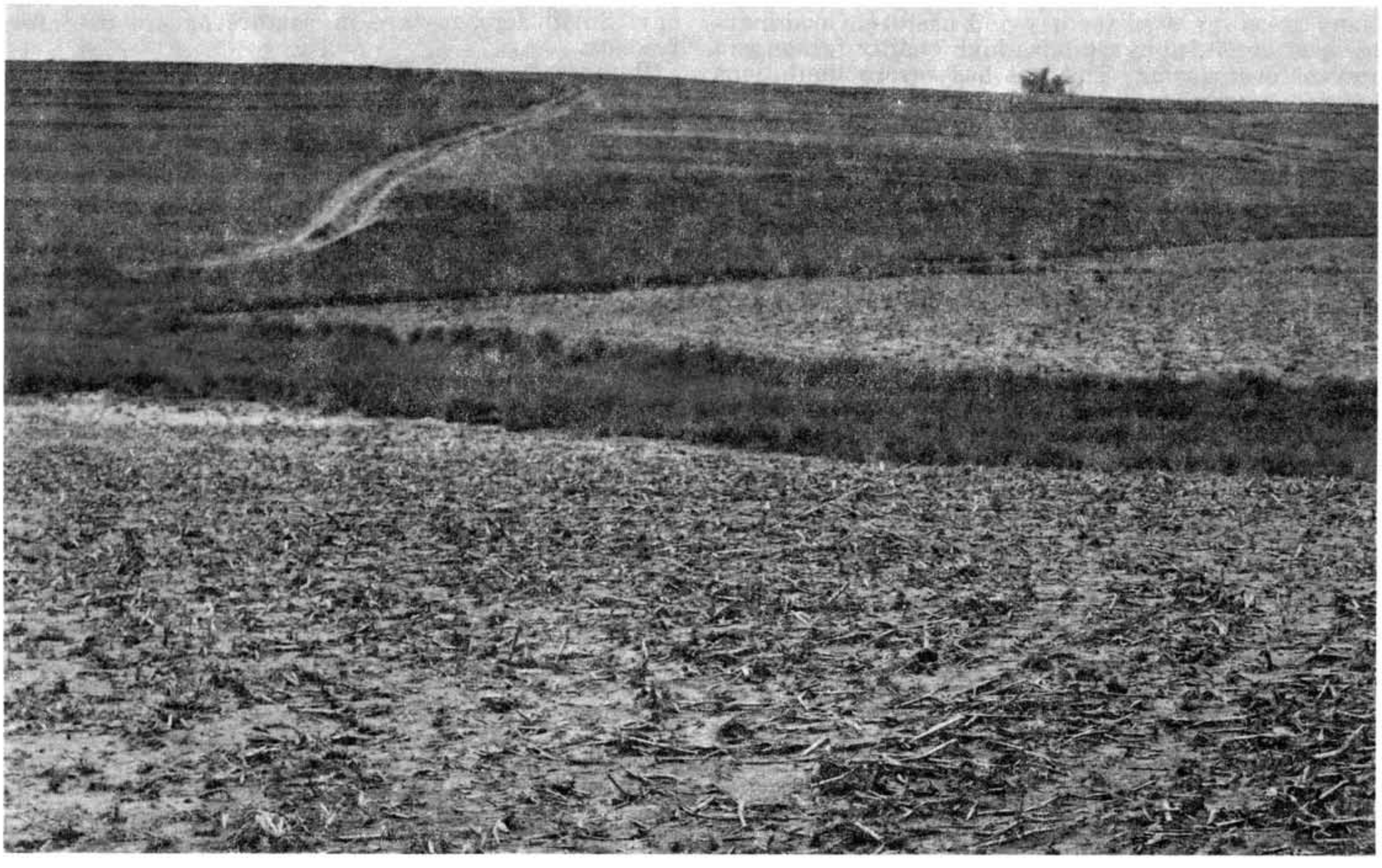


Figure 6.—**An area of Grundy silt loam, 2 to 5 percent slopes, on a high, broad, slightly undulating ridgetop in the northern part of the county.**

tillage practices and plowing down crop residue help to maintain tilth.

This soil is well suited to intensive cropping if erosion is controlled. Some areas are used for hay or pasture, and the main management concern is the prevention of overgrazing. The soil has moderate to severe limitations for most urban uses and moderate limitations for developing recreational facilities. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–5.

GrC—Grundy silt loam, 5 to 9 percent slopes. This soil is on the sloping parts around the outer edges of the broad tops of upland ridges and along the drainageways that finger back into the central parts of the ridgetops. The areas are typically longer than they are wide, or they are irregularly shaped. They range from about 3 to 90 acres in size. This soil has a profile similar to that described as representative of the series, but the silt loam surface layer in this soil is typically only about 7 or 8 inches thick.

Included with this soil in mapping are a few small areas of moderately well drained Sharpsburg and Gara soils. The Sharpsburg soils are along the higher parts of these areas and the Gara soils are in the lower parts. In some small areas slopes are slightly steeper than 9 percent. The soil in these spots generally has been severely eroded, and the plow layer is in the former upper part of the subsoil.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving and maintaining fertility and tilth. Because of the shape of the areas and the complex slopes, the use of terraces to control erosion is limited to either diversion terraces or to specific sites where the slopes are uniform enough for properly designed terrace systems. Waterways, contour farming, stripcropping, and conservation crop sequences help to control erosion. Minimum tillage practices and plowing down crop residue help to improve and maintain tilth.

This soil is well suited to crops if erosion is controlled. Many areas are used for hay and pasture, and the main management concern is the prevention of overgrazing. The soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–5.

Gullied Land

Gu—Gullied land. These miscellaneous areas are in the loess covered river hills inland from the steeply rising Missouri River bluffs. These areas consist of highly eroded hillsides where many deep, narrow gullies have dissected the smoothly rounded landforms of the former landscape into areas of jagged, deep, raw, steep sided ravines and thin knifelike ridges (fig. 7). Elevation between the tops and bottoms of these gullies and ravines ranges from about 10 to 75 feet, and many areas have isolated, pedestal like islands with top widths ranging from a few feet to as much as 300 feet. Drainageways or gully bottoms are narrow to wide and either are bare or partly covered by weeds, vines, and shrubs. Some gullies have delta type deposits of silty and sandy soil material at their outlets.

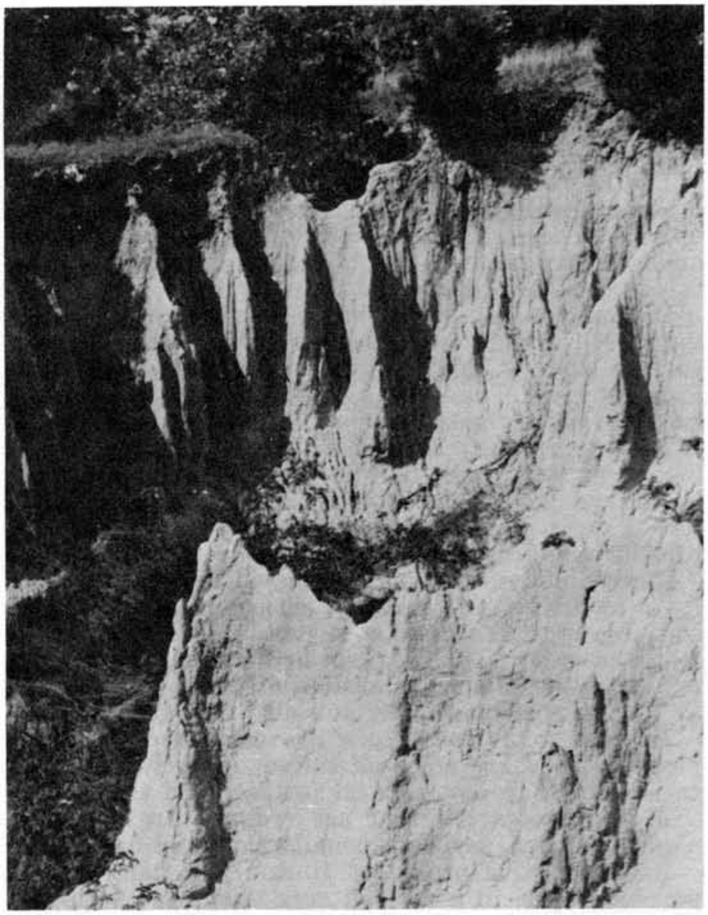


***Figure 7.*—This Gullied land in deep loess covered river hills resulted from overgrazing by livestock, mainly hogs.**

The areas are very irregular in shape and range from about 5 to 160 acres in size. Gullied land formed mostly in areas of moderately sloping to steep Menfro and Winfield soils. In many places the gullies have cut down into the underlying glacial till and gravelly sand material of glacial or alluvial origin. In a few places bedrock is exposed at lower elevations and in the bottoms of the ravines and gullies. Many areas have been used as dumps and are filled with rubbish, junk, and other debris.

Gullied land is poorly suited to any farm use, but it can be used as habitat for wildlife. In many areas Gullied land is subject to further accelerated erosion, and active gullies continue to extend into the surrounding landscape. The major management concerns are controlling further erosion and establishing an effective vegetative cover. Some areas can be helped by construction of diversion terraces and by providing erosion control structures to redirect flow of surface runoff. Other areas can benefit by such measures as reshaping, critical area seeding, mulching, and tree planting. For the most part, however, it is not economically feasible to reclaim the areas for normal uses. At best, these areas provide cover and some degree of seclusion for wildlife, but they lack the necessary elements to produce a dependable supply of food and water. Gullied land has severe limitations for development of recreational facilities and for urban uses. Capability unit VIIIe-1.

Hatton Series

The Hatton series consists of deep, moderately well drained, gently sloping to moderately sloping soils on uplands. These soils formed in thin loess deposits and underlying weathered glacial till. The natural vegetation is deciduous hardwood forest.

In a representative profile the surface layer is dark grayish brown silt loam about 3 inches thick. The subsurface layer is light yellowish brown silt loam about 5 inches thick. The upper part of the subsoil is strong brown, friable light silty clay loam. The middle part is brown, firm silty clay loam. The lower part is dark brown, firm silty clay that has strong brown and grayish brown mottles. It is underlain, at a depth of 37 inches, by a compact, mottled, yellowish brown, dark brown, and grayish brown silty clay loam fragipan.

Permeability is very slow, and available water capacity is moderate. The shrink-swell potential of the subsoil above the fragipan is moderate, and that of the fragipan is low. The fragipan is dense and hard when dry, and it restricts penetration of plant roots as well as the movement of water and air.

In most areas these soils are wooded or used for pasture. They are not well suited to cultivated crops because of their low natural fertility and the restrictive fragipan. Areas that are cropped are generally planted to corn, soybeans, small grain, and hay.

Representative profile of Hatton silt loam, 5 to 9 percent slopes, in a wooded area about 100 feet west of the center of sec. 23, T. 51 N., R. 14 W.:

A1—0 to 3 inches; dark grayish brown (10YR 4/2) silt loam; weak very fine granular structure; very friable; many fine roots; strongly acid; abrupt wavy boundary.

A2—3 to 8 inches; light yellowish brown (10YR 6/4) silt loam; weak fine platy structure; very friable; common fine roots; strongly acid; clear wavy boundary.

B1—8 to 18 inches; strong brown (7.5YR 5/6) light silty clay loam; moderate very fine and fine subangular structure; friable; strongly acid; clear smooth boundary.

B21t—18 to 28 inches; brown (7.5YR 5/4) silty clay loam; moderate fine subangular structure; firm; few thin silt coatings on vertical ped faces and along cracks; strongly acid; clear smooth boundary.

B22t—28 to 37 inches; dark brown (7.5YR 4/4) silty clay; common fine distinct strong brown (7.5YR 5/6) and grayish brown (10YR 5/2) mottles; moderate coarse angular blocky structure; firm; thin continuous clay films on ped faces; many dark stains of iron and manganese oxides on ped faces; strongly acid; abrupt smooth boundary.

IIBx1—37 to 46 inches; mottled yellowish brown (10YR 5/6), dark brown (10YR 4/3), and grayish brown (10YR 5/2) silty clay loam; weak coarse prismatic structure parting to weak coarse blocky; very firm; compact with weakly expressed brittleness when moist; thin gray silt coatings and dark brown clay films on vertical ped faces and prisms; many dark stains and fine soft granules of iron and manganese oxides; very strongly acid; gradual smooth boundary.

IIBx2—46 to 60 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) light silty clay loam; weak coarse and very coarse prismatic structure; hard when dry, compact with very weakly expressed brittleness when moist; thick silt coatings along vertical surfaces and cracks; strongly acid.

The solum ranges from 30 to 60 inches or more in thickness. Depth to the fragipan is typically 27 to 38 inches. The A horizon is dark brown or dark grayish brown when plowed. It is strongly acid or medium acid in reaction, except where limed. The B1 horizon is heavy silt loam or light silty clay loam. It is strongly acid or very strongly acid. The B21t horizon is brown or strong brown and is also strongly acid or very strongly acid. The B22t horizon is dark brown or dark yellowish brown and has fine or medium, distinct mottles of grayish brown or light brownish gray accompanied by yellowish brown, strong brown, or yellowish red mottles. It is heavy silty clay loam or silty clay and is strongly acid or very strongly acid. The IIBx1 horizon has weakly to moderately expressed brittleness when moist and hardness when dry within short horizontal distances. The IIBx horizon ranges from very weakly expressed to moderately expressed in compactness, brittleness, and hardness within both short horizontal and vertical distances. It is light silty clay loam or silt loam.

Hatton soils are near Lindley, Keswick, and Marion soils. They have a finer textured subsoil than Lindley soils and a fragipan that is lacking in Lindley, Keswick, and Marion soils. Hatton soils are not as wet as Marion soils.

HaB—Hatton silt loam, 2 to 5 percent slopes. This soil is on the narrow, slightly convex tops of high ridges in the uplands. The areas are very long, narrow, and irregularly shaped. They range from about 5 to 300 acres in size. This soil has a profile similar to that described as representative of the series, but in cultivated areas it has a dark grayish brown silt loam surface layer about 7 to 9 inches thick.

Included with this soil in mapping are a few areas where slopes are steeper than 5 percent. Also included are cultivated areas where the plow layer is mostly in the upper part of the subsoil and is silty clay loam. In places small areas of moderately well drained Weller soils and poorly drained Marion soils are included in mapping. These soils occupy flat to slightly concave areas on the wider parts of ridgetops.

Runoff is medium, and the hazard of erosion is slight to moderate. The main concerns of management are controlling erosion and improving tilth, fertility, and organic matter content. Most areas of this soil are too narrow for terraces, and the need for grassed waterways to control erosion depends mostly on how the soils on the adjacent side slopes are used. Contour farming has a limited use in some areas, but crop sequences that include grain and hay are probably the most effective means of cropping these soils and keeping erosion to a minimum. Plowing under crop residue, using green manure crops, and using minimum tillage practices help to build up organic matter content and maintain tilth.

Most areas of this soil are not well suited to intensive cropping because of their long, narrow shapes and poor landscape position next to steep glacial till soils on the side slopes. Many areas are used for hay and pasture, and good management is needed to establish a high quality forage cover and prevent overgrazing. These soils have moderate to severe limitations for urban uses and slight to moderate limitations for developing recreational facilities. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–4.

HaC—Hatton silt loam, 5 to 9 percent slopes. This soil is on the narrow convex tops of high ridges in the uplands. The areas are very long, narrow, and irregularly shaped. They range from about 5 to 160 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of the moderately drained Keswick soils and the well drained Lindley soils. Also included are small spots on the upper parts of slopes in cultivated areas where the silt loam surface layer has been eroded and the silty clay loam upper part of the subsoil is exposed.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving tilth, fertility, and organic matter content. Most of the areas are too narrow and irregularly shaped for use of terraces to control erosion. Contour farming methods have a limited use in some areas, but cropping sequences that include small grains and hay are probably the most effective means of cropping these soils and keeping erosion to a minimum. Plowing under crop residue, using green manure crops, and using minimum tillage practices help to improve tilth and organic matter content.

This soil is not suited to intensive cropping. A better use is for hay and pasture or woodland. Hay and pasture areas need good management to establish a high quality forage cover and prevent overgrazing. The soil has moderate to severe limitations for urban uses and slight to severe limitations for developing recreational facilities. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–4.

Haynie Series

The Haynie series consists of deep, well drained, level to nearly level soils on bottom land of the Missouri River. These soils formed in the silty alluvial sediment derived both locally and throughout the vast drainage area of the Missouri River and its tributaries. The native vegetation is a relatively thin, unstable cover of grasses, shrubs, and trees.

In a representative profile the surface layer is very dark grayish brown silt loam about 7 inches thick. It is underlain, to a depth of 60 inches, by stratified, friable silt loam and very friable very fine sandy loam. The strata are dark grayish brown or brown, but a few yellowish brown and dark yellowish brown mottles are below a depth of about 30 inches.

Permeability is moderate, and available water capacity is high. Areas unprotected by levees are subject to flooding late in winter and in spring. The shrink-swell potential throughout this soil is low.

Most areas of these soils are cultivated, and the main crops are corn, soybeans, small grains and hay. Many of the levee protected areas of Haynie soils are double cropped with such crops as winter wheat and soybeans. Only a few areas are used for pasture, and some small areas are wooded.

Representative profile of Haynie silt loam about one mile east of Bonne Femme Creek and 100 feet north of U. S. Highway 40 in the south central part of survey 2451, T. 49 N., R. 16 W.:

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam; moderate medium granular structure; very friable; mildly alkaline; abrupt smooth boundary.

C1—7 to 11 inches; dark grayish brown (10YR 4/2) silt loam; weak medium granular structure; friable; mildly alkaline; slight effervescence; clear smooth boundary.

C2—11 to 18 inches; brown (10YR 4/3) silt loam; weak medium subangular blocky structure; friable; mildly alkaline; slight effervescence; clear smooth boundary.

C3—18 to 30 inches; dark grayish brown (10YR 4/2) very fine sandy loam; weak medium subangular blocky structure; very friable; mildly alkaline; slight effervescence; gradual smooth boundary.

C4—30 to 60 inches; dark grayish brown (10YR 4/2) very fine sandy loam; few medium distinct, yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4) mottles; massive; very friable; moderately alkaline; strong effervescence.

The Ap horizon is very dark grayish brown or very dark gray. The C horizon is dominantly dark brown, brown, or dark grayish brown. Mottles of yellowish brown, dark yellowish brown, strong brown, grayish brown, light brownish gray, or gray are below a depth of 24 inches. The C horizon is mildly to moderately alkaline in reaction and contains free carbonates throughout. It is stratified silt loam in the upper part and very fine sandy loam with thin strata, lenses, and pockets of fine sand, loamy fine sand, fine sandy loam, very fine sand, and loamy very fine sand below a depth of about 18 inches.

Haynie soils are near Carlow, Leta, Hodge, and Nodaway soils. They contain less clay and are not so wet as Carlow and Leta soils. Haynie soils contain more silt and clay than Hodge soils. They contain free carbonates that Nodaway soils lack, and are not so wet as Nodaway soils.

Hn—Haynie silt loam. This level to nearly level soil is on low, slightly convex ribbonlike ridges and small mounds and in large areas of the Missouri River bottom land. The areas are round, long and narrow, or irregular in shape and range from 3 to about 600 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of well drained Hodge soils. Also included are small areas of somewhat poorly drained Leta soils in depressions and narrow drainageways. In a few areas short slopes are steeper than 2 percent.

Runoff is slow, and the hazard of erosion is slight. The main concerns of management are improving fertility, building up organic matter content, and maintaining tilth. Plowing under of crop residue and using minimum tillage practices help to build up the organic matter content and maintain good tilth.

This soil is well suited to intensive cropping. Unprotected areas, however, are subject to flooding, and at times, even protected areas are subject to flooding. The areas are not commonly used for pasture, but they provide good quality grass and legume hay and forage. The soil has severe limitations for urban uses and slight to severe limitations for developing recreational facilities. Suitability as habitat for open land and woodland wildlife is fair. Capability unit I–1.

Hodge Series

The Hodge series consists of deep, well drained, level to nearly level soils on bottom land of the Missouri River. These soils formed in sandy alluvium deposited during overflows and floods of the past 200 to 300 years. The native vegetation is a relatively thin, unstable cover of grasses, shrubs, and trees.

In a representative profile the surface layer is dark grayish brown loamy fine sand about 9 inches thick. It is underlain, to a depth of 60 inches, by dark grayish brown and brown, loose loamy fine sand.

Permeability is rapid, and available water capacity is low. Areas unprotected by levees are subject to flooding late in winter and in spring. Shrink-swell potential is low.

Many areas of these soils are cultivated. The soils have low natural fertility, and crop production is extremely variable. Corn, soybeans, small grains, and hay are the main crops. A few areas are in pasture, and several areas are wooded.

Representative profile of Hodge loamy fine sand in a cultivated field about 300 feet north and 2,000 feet west of the southeast corner of sec. 10, T. 49 N., R. 18 W.:

Ap—0 to 9 inches; dark grayish brown (10YR 4/2) loamy fine sand; weak medium granular structure; very friable; mildly alkaline; slight effervescence; abrupt smooth boundary.

C1—9 to 22 inches; dark grayish brown (10YR 4/2) loamy fine sand; single grained; loose; mildly alkaline; slight effervescence; gradual smooth boundary.

C2—22 to 42 inches; dark grayish brown (10YR 4/2) loamy fine sand; single grained; loose when dry; mildly alkaline; slight effervescence; gradual smooth boundary.

C3—42 to 60 inches; brown (10YR 4/3) loamy fine sand; single grained; loose when dry; mildly alkaline.

The Ap horizon is dark grayish brown, dark brown, or brown and is dominantly loamy fine sand, but the range includes fine sand. It is neutral or mildly alkaline in reaction. The C horizon is dark grayish brown, dark brown, or brown. It is stratified loamy fine sand or fine sand that has thin strata or lenses of silt, silt loam, or very fine sandy loam. The C horizon is neutral or mildly alkaline. It commonly contains free carbonates in the lower parts.

Hodge soils are near Carlow, Haynie, Leta, and Nodaway soils. They have a lower content of silt and clay throughout their solum than all of these soils. They are not so wet as the Carlow and Leta soils.

Ho—Hodge loamy fine sand. This soil is on low ridgelike mounds and in nearly level to slightly undulating areas of the landscape on Missouri River bottom land. The latter areas are generally near the active river channel. They range from long and narrow to irregular in shape and from 2 to 200 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of well drained Haynie soils. A few small depressions and troughlike sloughs that have soils similar to the somewhat poorly drained Leta soils are also included in places.

Runoff is slow, and the hazard of erosion by water other than flood water is slight. This sandy soil is subject to moderate or severe soil blowing when cultivated or only sparsely covered by vegetation. Where areas are not protected by levees, the soil is subject to large washouts, mass deposits of new sediment, and constant reshaping by overflowing and retreating flood waters. The erosion and deposition need to be controlled by a permanent cover of trees, shrubs, and grasses. Good management of farmed areas includes a conservation cropping sequence that includes cover crops. Also, crop residue needs to be returned to the soil. Minimum tillage, use of windbreaks, and wind protective stripcropping help to control erosion and prevent excess moisture losses caused by wind. Additions of plant nutrients, farm manure, and other organic waste material help to improve fertility and build up organic matter content.

This soil is poorly suited to most kinds of general farming. Some areas could be used for such specialized crops as small fruits or vegetables by applying intensive management and irrigation practices. A few areas are used for pasture. The soil has slight to severe limitations for urban uses and recreational development. Suitability as habitat for wildlife is fair to very poor. Capability unit IIIs–1.

Keswick Series

The Keswick series consists of deep, moderately well drained, moderately sloping to strongly sloping soils on uplands. These soils formed in a very thin mantle of loess and the underlying old glacial till. The native vegetation is deciduous trees.

In a representative profile the surface layer is very dark grayish brown loam about 5 inches thick. The subsurface layer is brown loam about 5 inches thick. The upper part of the subsoil is reddish brown and yellowish red firm clay; the middle part is mottled, yellowish red and grayish brown firm clay; and the lower part, to a depth of 60 inches, is grayish brown, firm clay loam that has yellowish red and yellowish brown mottles.

Permeability is slow, and available water capacity is moderate. The shrink-swell potential of the subsoil is high.

Most areas of these soils are used for pasture or hay. Some areas have never been cleared and remain wooded. A few areas are cultivated and planted mostly to corn, small grains, and hay. Where they are uneroded, these soils have medium natural fertility, but where they are eroded, fertility is low. Wooded areas are mostly second growth oak and hickory.

Representative profile of Keswick loam in a wooded area of Lindley and Keswick loams, 9 to 14 percent slopes, about 2,200 feet east and 400 feet north of the southeast corner of sec. 35, T. 52 N., R. 15 W.:

A1—0 to 5 inches; very dark grayish brown (10YR 3/2) loam; moderate fine granular structure; very friable; medium acid; clear smooth boundary.

A2—5 to 10 inches; brown (10YR 5/3) loam; weak fine granular structure; very friable; strongly acid; abrupt smooth boundary.

IIB21t—10 to 13 inches; reddish brown (5Y 4/4) clay; moderate medium subangular blocky structure; firm; very plastic when wet; thin patchy pale brown (10YR 6/3) silt coatings on ped faces; strongly acid; abrupt wavy boundary.

IIB22t—13 to 20 inches; yellowish red (5YR 5/6) clay; few fine faint, brown (10YR 5/3) mottles; weak fine angular blocky structure; very firm; very plastic when wet; thick continuous clay films on all ped faces; strongly acid; clear smooth boundary.

IIB23t—20 to 26 inches; mottled yellowish red (5YR 4/6) and grayish brown (2.5Y 5/2) clay; weak medium angular blocky structure; very firm; thick continuous clay films on all ped faces; strongly acid; clear smooth boundary.

IIB24t—26 to 34 inches; grayish brown (2.5Y 5/2) heavy clay loam; many medium distinct yellowish red (5YR 4/6) mottles; weak medium blocky structure; firm; common pressure faces on vertical surface of peds; medium acid; clear smooth boundary.

IIB3—34 to 60 inches; mottled grayish brown (2.5Y 5/2), yellowish brown (10YR 5/6), and yellowish red (5YR 4/6) clay loam; weak medium subangular blocky structure; firm; medium acid.

The solum ranges from about 42 to 60 inches or more in thickness. The A1 horizon is very dark gray or very dark grayish brown. In plowed areas the Ap horizon is typically dark grayish brown and is about 6 to 10 inches thick. The A horizon is dominantly loam, but the range includes silt loam. It is commonly strongly acid or medium acid in reaction. In some profiles the lower part of the A horizon has a thin band of pebbles. The IIB2 horizon is clay or heavy clay loam and very strongly acid to medium acid. The IIB3 horizon is light clay loam or clay loam and is strongly acid or medium acid.

These soils are grayer in lower parts of the subsoil than is defined in the range for the series, but this difference does not alter their usefulness and behavior.

Keswick soils are mapped as a complex with the Lindley soils. They are near Hatton, Mandeville, Menfro, Norris, and Winfield soils. Keswick soils have a higher clay content in their subsoil and are wetter than the Lindley and Menfro soils. They lack the fragipan below the subsoil that is characteristic of Hatton soils. Keswick soils are deep and lack the underlying shale bedrock within a depth of 40 inches of the Mandeville soils and shallower Norris soils. They have a higher clay content in their subsoil than Winfield soils.

Knox Series

The Knox series consists of deep, well drained, moderately sloping to steep soils on uplands. These soils formed in thick deposits of loess. The native vegetation is deciduous trees and prairie grasses.

In a representative profile the surface layer is dark brown silt loam about 7 inches thick. The subsurface layer is dark brown silt loam about 4 inches thick. The upper 21 inches of the subsoil is dark yellowish brown, firm heavy silt loam, and the lower 6 inches is yellowish brown, friable silt loam. The subsoil is underlain, at a depth of about 38 inches, by yellowish brown silt loam.

Permeability is moderate, and available water capacity is high. Shrink-swell potential is low throughout these soils.

Many areas of these soils are cultivated. They have a high natural fertility if uneroded, but in most areas the soils are eroded. The exposed subsoil has only medium natural fertility. Areas of less sloping soils are planted mainly to corn, soybeans, and small grains; areas of steeper soils are used for grass and legume hay or for pasture. A few small patches of tobacco are grown on these soils. Wooded areas are mostly confined to the steepest slopes and along the draws and drainageways.

Representative profile of Knox silt loam, 5 to 9 percent slopes, at the edge of a cultivated field and wooded area, about 1,000 feet north and 700 feet east of the southwest corner of sec. 21, T. 51 N., R. 17 W.:

Ap—0 to 7 inches; dark brown (10YR 3/3) silt loam; moderate medium granular structure; very friable; neutral; clear smooth boundary.

A2–7 to 11 inches; dark brown (10YR 4/3) silt loam; moderate fine subangular blocky structure; very friable; common dark brown (10YR 3/3) coatings on ped faces; neutral; gradual smooth boundary.

B21t—11 to 21 inches; dark yellowish brown (10YR 4/4) heavy silt loam; moderate medium subangular blocky structure; firm; thin patchy dark brown coatings on ped faces; neutral; gradual smooth boundary.

B22t—21 to 32 inches; dark yellowish brown (10YR 4/4) heavy silt loam; weak medium subangular blocky structure; firm; neutral; gradual smooth boundary.

B3—32 to 38 inches; yellowish brown (10YR 5/4) silt loam; weak medium subangular blocky structure; friable; neutral; gradual smooth boundary.

C—38 to 60 inches; yellowish brown (10YR 5/4) silt loam; massive; friable; mildly alkaline; calcareous.

The solum ranges from about 36 inches to 50 inches in thickness. The Ap horizon is very dark grayish brown or dark brown and medium acid to neutral in reaction, depending on local practices of liming. The A2 horizon is dark brown when moist and pale brown when dry. Reaction ranges from medium acid to neutral. The B2t horion is dark yellowish brown or dark brown heavy silt loam or silty clay loam. It ranges from medium acid to neutral. The B3 horizon is yellowish brown and in places has streaks of strong brown. Reaction is slightly acid or neutral. The C horizon is dominantly yellowish brown but has streaks of strong brown and occasional horizontal bands of light brownish gray about 1 to 4 inches thick. It typically contains free carbonates.

These soils contain free carbonates at depths less than in the defined range for the series, but this difference does not alter their usefulness or behavior.

Knox soils are near Marshall, Menfro, Norris, and Winfield soils. They have a thinner dark surface layer than Marshall soils. Knox soils have a darker surface layer than Menfro soils. They are deep and lack the weathered shale bedrock within a depth of less than 20 inches that is characteristic of Norris soils. Knox soils are not so wet as Woodfield soils, and they lack the gray colors in the lower part of the subsoil that are characteristic of Winfield soils.

KnC—Knox silt loam, 5 to 9 percent slopes. This soil is on the strongly dissected uplands and river bluffs bordering the valley of the Missouri River. It is on the tops and upper parts of the side slopes of the hills and ridges. Areas of this soil are highly irregular in shape and range from about 8 to 250 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of well drained Menfro and Marshall soils. Some small areas where slopes are more than 9 percent as well as a few areas where slopes are less than 5 percent are also included. In some areas the surface layer has been eroded away, and the plow layer is the former upper part of the dark yellowish brown subsoil.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving and maintaining fertility and organic matter content. Use of conservation cropping sequences, terraces, grassed waterways, stripcropping techniques, and cover crops help in controlling erosion. Plowing down crop residue and using green manure crops will help to maintain and build up organic matter content. Minimum tillage helps to control erosion and maintain tilth and organic matter content.

This soil is moderately well suited to crops where erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to moderate limitations for most urban uses and slight to severe limitations for recreational projects. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–1.

KnD3—Knox silt loam, 9 to 14 percent slopes, severely eroded. This soil is on the strongly dissected uplands and river bluffs bordering the valley of the Missouri River. It is on narrow ridges and hilltops as well as on complex side slopes. Many areas have been dissected by deeply entrenched drainageways, ravines, and small secondary streams. The areas are irregularly shaped and range from about 3 to 180 acres in size. This soil has a profile smilar to that described as representative of the series. Most of the surface layer has been eroded away, however, and the plow layer is mainly the former upper part of the subsoil.

Included with this soil in mapping are small areas of well drained Menfro and Marshall silt loams and a few areas of moderately well drained Winfield soils. Also included are some small areas of well drained Lindley loams and Norris silt loams that are on the lower parts of side slopes and in escarpmentlike spots along streams and ravines.

Runoff is rapid, and the hazard of erosion is severe. Controlling erosion, improving fertility, and building up the organic matter content are the major concerns of management. The use of diversion terraces, grassed waterways, stripcropping techniques, and conservation crop sequences that include small grains and hay help in controlling erosion. Plowing down of crop residue helps to build up the organic matter content.

This soil is not suited to intensive cropping, but where erosion is controlled production of most locally adapted crops is good. Many areas are used for pasture, and good management is needed to establish high quality forage and prevent overgrazing. The soil has moderate to severe limitations for most urban uses and slight to severe limitations for recreational projects. Suitability as habitat for open land and woodland wildlife is good. Capability unit IVe–4.

KnE3—Knox silt loam, 14 to 30 percent slopes, severely eroded. This soil is on the strongly dissected uplands and river bluffs bordering the valley of the Missouri River. It is mostly on the side slopes. The areas are irregularly shaped, and they range from about 7 to 600 acres in size. This soil has a profile similar to that described as representative of the series, but the surface layer has been completely eroded away and the plow layer is the former upper part of the subsoil.

Included with this soil in mapping are small areas of well drained Menfro silt loams and moderately well drained Winfield silt loams. Also included are a few small areas of well drained Lindley loams and shallow to bedrock Norris silt loams that are mostly on the lower parts of the side slope or escarpmentlike positions along the narrow valleys and ravines.

Runoff is very rapid, and the hazard of erosion is very severe. The main concern of management is controlling erosion. Since steepness of slope limits the kind of erosion control measures that can be applied, better use of this soil is for permanent grass-legume hay or pasture. Good management is needed to establish high quality forage, and prevention of overgrazing is a necessary precaution in pastures.

This soil is not suited to intensive cropping, and it has limitations for such cropping sequences as small grains and hay. It has severe limitations for most urban uses and recreational development. Suitability as open land wildlife habitat is fair, and suitability as woodland wildlife habitat is good. Capability unit VIe-4.

Ladoga Series

The Ladoga series consists of deep, moderately well drained, gently sloping to moderately sloping soils on uplands. These soils formed in moderately thick deposits of loess. The native vegetation is deciduous trees and prairie grasses.

In a representative profile the surface layer is very dark grayish brown silt loam about 7 inches thick. The subsurface layer is dark grayish brown silt loam about 4 inches thick. The upper part of the subsoil is dark brown, friable light silty clay loam and firm heavy silty clay loam. The middle part is grayish brown, firm silty clay loam mottled with yellowish brown. The lower part, to a depth of 60 inches, is grayish brown friable silt loam mottled with strong brown.

Permeability is moderately slow, and available water capacity is high. The shrink-swell potential of the subsoil is moderate to high.

Most areas of these soils are cultivated, and they have a medium natural fertility. The main crops are corn, soybeans, small grains, and grass and legume hay. Some areas are in pasture, and a few areas are wooded.

Representative profile of Ladoga silt loam, 2 to 5 percent slopes, in a cultivated field, about 1,740 feet south and 50 feet west of the northeast corner of sec. 21, T. 50 N., R. 15 W.:

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silt loam; moderate fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A2—7 to 11 inches; dark grayish brown (10YR 4/2) silt loam; weak medium platy structure parting to weak fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

B1—11 to 16 inches; dark brown (10YR 4/3) light silty clay loam; weak fine subangular blocky structure; friable; common thin silt coatings on ped faces; medium acid; gradual smooth boundary.

B21t—16 to 29 inches; brown (10YR 4/3) heavy silty clay loam; moderate medium subangular blocky structure; firm; thin discontinuous clay films on ped faces; strongly acid; gradual smooth boundary.

B22t—29 to 46 inches; grayish brown (10YR 5/2) silty clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; firm; common fine dark concretions and iron stains; thin patchy clay films on ped faces; strongly acid; gradual smooth boundary.

B23t—46 to 56 inches; grayish brown (10YR 5/2) silty clay loam; many fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium subangular blocky structure; firm; thin patchy clay films on ped faces; common fine dark concretions and iron stains; medium acid; gradual wavy boundary.

B3—56 to 60 inches; grayish brown (10YR 5/2) silt loam; common fine distinct strong brown (7.5YR 5/6) mottles; weak medium subangular blocky structure; friable; common fine dark concretions; medium acid.

The solum ranges from about 40 to 60 inches or more in thickness. The Ap horizon is very dark gray, very dark grayish brown, or very dark brown. It is slightly acid or neutral. The A2 horizon is strongly acid or medium acid, but it is lacking in some profiles. The B1 horizon is also lacking in some profiles. The B21t horizon is dark brown or dark yellowish brown and is strongly acid or medium acid. It is medium to heavy silty clay loam. The B22t and B23t horizons are medium acid. The B3 horizon is silt loam or light silty clay loam, and it ranges from strongly acid to slightly acid.

These soils have gray color at a depth less than that in the defined range for the series, but this difference does not alter their usefulness or behavior.

Ladoga soils are near Armstrong, Gara, Marion, Pershing, and Weller soils. They have a slightly lower clay content in the subsoil than Armstrong soils, and they lack the reddish mottles and contain less fine sand or coarse particles than those soils. Ladoga soils formed completely in loess, and Gara soils formed in glacial till. Ladoga soils contain less fine sand or coarse particles than Gara soils. They have a lower clay content in the subsoil than Marion, Pershing, and Weller soils and are not so wet as those soils. Ladoga soils also have a darker surface layer than Weller soils.

LaB—Ladoga silt loam, 2 to 5 percent slopes. This soil is on narrow to moderately wide moundlike ridgetops of upland divides. The areas are irregularly shaped but commonly are longer than they are wide. They range from 3 to 200 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of moderately well drained Sharpsburg silt loam, Winfield silt loam, and Gara loam. On the wider ridgetops are small areas of somewhat poorly drained Pershing silt loam and Grundy silt loam that occupy flat spots or slight depressions at the heads of drainageways.

Runoff is medium, and the erosion hazard is moderate. The main concerns of management are controlling erosion and improving tilth and fertility. Because of the long, narrow shape of the areas and the ridgetop positions of this soil, terrace systems are generally not constructed for its protection. Instead, they are mainly designed to accommodate the soils immediately adjacent to this soil. Conservation cropping sequences, minimum tillage, and cover crops help to control erosion. Returning crop residues to the soil and using green manure crops help to build up the organic matter content and maintain conditions of good tilth.

This soil is well suited to intensive cropping. Some areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to severe limitations for urban uses and slight to moderate limitations for recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–4.

LaC—Ladoga silt loam, 5 to 9 percent slopes. This soil is on side slopes and rounded tops of moderately wide ridges of upland divides. The areas are irregularly shaped and range from about 2 to 250 acres in size. This soil is similar to that described as representative of the series except the surface layer is commonly slightly thinner, and the subsurface and surface layers have been mixed together in plowing.

Included with this soil in mapping are small areas of moderately well drained Sharpsburg silt loam, Winfield silt loam, and Gara loam. Also included are a few small areas where slopes are more than 9 percent and spots where loess is 20 to 40 inches thick over old glacial till. In a few small areas along the lower parts of side slopes, the underlying bedrock is at a depth of 50 inches or less.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion, improving fertility, and maintaining tilth. Terrace systems, grass waterways, stripcropping, conservation crop sequences, and cover crops help to control erosion. Minimum tillage, return of crop residue, and use of green manure crops help to maintain the organic matter content and tilth.

This soil is suited to most crops where erosion is controlled. Many areas are used for pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–4.

Leta Series

The Leta series consists of deep, somewhat poorly drained, level to nearly level soils on bottom land of the Missouri River. These soils formed in silty and clayey alluvial sediment. The native vegetation is mostly deciduous trees, wetland shrubs, and some sedges and grasses.

In a representative profile the surface layer is very dark grayish brown silty clay in the upper 7 inches and very dark gray silty clay in the lower 12 inches. The subsoil is very dark grayish brown, very firm silty clay that has dark gray and dark yellowish brown mottles. It is about 15 inches thick. It is underlain by a layer of dark gray and grayish brown, friable silt loam at a depth of about 34 inches and dark grayish brown, firm clay at a depth of 40 inches.

Permeability is slow, and available water capacity is moderate. A seasonal high water table is present in winter and in spring. The shrink-swell potential is high throughout the clayey parts of these soils. The soils are subject to flooding in areas unprotected by levees and subject to ponding in slightly depressed areas and old sloughs.

Most areas of these soils are cultivated. The main crops are corn, soybeans, and small grains. The soils have a medium natural fertility. A few areas are in pasture or are wooded.

Representative profile of Leta silty clay in a cultivated field about 800 feet west and 300 feet south of the northeast corner of survey 2626, T. 48 N., R. 17 W.:

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) silty clay; moderate medium granular structure; firm; mildly alkaline; abrupt smooth boundary.

A11—7 to 10 inches; very dark gray (10YR 3/1) silty clay; moderate fine subangular blocky structure; firm; neutral; gradual smooth boundary.

A12—10 to 19 inches; very dark gray (10YR 3/1) silty clay; moderate medium subangular blocky structure; firm; neutral; gradual smooth boundary.

B2—19 to 34 inches; very dark grayish brown (2.5Y 3/2) silty clay; few fine faint dark gray (10YR 4.1) and dark yellowish brown (10YR 4/4) mottles; moderate coarse angular blocky structure; very firm; slightly plastic; mildly alkaline; clear smooth boundary.

IIC1g—34 to 40 inches; dark gray (10YR 4/1) and grayish brown (2.5Y 5/2) silt loam; common medium brown (10YR 5/3) mottles; weak medium subangular blocky structure; friable; moderately alkaline; calcareous; clear smooth boundary.

IIIC2g—40 to 60 inches; dark grayish brown (2.5Y 4/2) silty clay; common fine distinct yellowish brown and gray (10YR 5/1) mottles; weak coarse angular blocky structure; firm; moderately alkaline; calcareous.

The solum ranges from 20 to 38 inches in thickness. The A horizon is very dark grayish brown or very dark gray silty clay or silty clay loam. It is neutral or mildly alkaline in reaction. The B2 horizon is very dark grayish brown or dark grayish brown silty clay or heavy silty clay loam. In some profiles it contains free carbonates. The IIC horizon is stratified, and the strata range from thin to thick silt loam, very fine sandy loam, silty clay loam, and silty clay. Some profiles have thin strata of loamy fine sand and fine sandy loam. The IIC horizon is mildly alkaline or moderately alkaline in reaction. It contains free carbonates.

These soils have a thicker dark colored surface layer than is defined in the range for the series. Also, free carbonates and the finer textured underlying material are deeper than is defined in the range for the series. These differences, however, do not alter usefulness or behavior of the soils.

Leta soils are near Carlow, Haynie, Hodge, and Nodaway soils. They are not so wet or so clayey throughout their profile as the Carlow soils. Leta soils are more poorly drained and have more clay in the upper 40 inches than Haynie and Nodaway soils. They are more poorly drained and finer textured throughout their profile than Hodge soils.

Le—Leta silty clay. This soil is on level to slightly concave and depressed areas of Missouri River bottom land. The areas range from long and narrow to irregular in shape and from about 5 to 800 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of poorly drained Carlow silty clay. Also included are small areas of well drained Haynie silt loam and, along the boundary lines where these two soils join, areas of Leta soils that have a thin silt loam surface layer.

Runoff is slow, and depressed areas are subject to brief periods of ponding. Flooding, removing excess water, and maintaining tilth are the major concerns of management. The use of dikes, ditches, land grading, and large flood control measures help to remove excess water and control flooding. The plowing down of crop residue and green manure crops and the use of minimum tillage methods help to improve tilth. Timing plowing and planting operations to concur with optimum soil moisture conditions is extremely important. Fall plowing is beneficial in most cases.

This soil is suited to crops where flooding is controlled or is infrequent. It has severe limitations for urban uses and recreational development. Suitability as habitat for open land wildlife is fair, and suitability as habitat for woodland wildlife is good. Capability unit IIw-2.

Lindley Series

The Lindley series consists of deep, well drained, moderately sloping to steep soils on uplands. These soils formed in loamy glacial till. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark grayish brown loam about 3 inches thick. The subsurface layer is brown loam about 4 inches thick. The subsoil is firm clay loam about 39 inches thick. The upper 25 inches of the subsoil is strong brown, and the lower 14 inches is strong brown with grayish brown and brown mottles. The underlying material is mottled, yellowish brown and light brownish gray clay loam.

Permeability is moderately slow, and available water capacity and shrink-swell potential are moderate.

Most areas of these soils are used for pasture, hay, or woodland. Natural fertility is medium, but the steepness of the slopes has limited the use of these soils for cultivated crops. A few areas are in corn, small grains, soybeans, and hay.

Representative profile of Lindley loam, 14 to 30 percent slopes, in a wooded area about 2,500 feet south and 400 feet east of the northeast corner of sec. 35, T. 52 N., R. 15 W.:

A1—0 to 3 inches; dark grayish brown (10YR 4/2) loam; weak fine granular structure; very friable; strongly acid; abrupt irregular boundary.

A2—3 to 7 inches; brown (10YR 5/3) loam; weak fine granular structure; very friable; very strongly acid; clear smooth boundary.

B1t—7 to 9 inches; strong brown (7.5YR 5/6) light clay loam; strong fine subangular blocky structure; firm; thin brown silt coating on some ped faces; very strongly acid; abrupt smooth boundary.

B21t—9 to 18 inches; strong brown (7.5YR 5/6) clay loam; moderate medium subangular blocky structure; firm thin continuous clay films on ped faces; very strongly acid; gradual smooth boundary.

B22t—18 to 25 inches; strong brown (7.5YR 5/6) clay loam; moderate coarse subangular blocky structure; firm; thin continuous clay films on ped faces; very strongly acid; gradual smooth boundary.

B23t—25 to 34 inches; strong brown (7.5YR 5/6) clay loam; many fine distinct grayish brown (10YR 5/2) mottles; moderate coarse subangular blocky structure; firm; thin patchy clay films on ped faces; few clean sand grains; very strongly acid; gradual smooth boundary.

B24t—34 to 46 inches; strong brown (7.5YR 5/6) clay loam; few fine distinct brown (10YR 5/3) and grayish brown (10YR 5/2) mottles; weak coarse subangular blocky structure; firm; very strongly acid; gradual smooth boundary.

C—46 to 60 inches; mottled yellowish brown (10YR 5/6) and light brownish gray 2.5Y 6/2) clay loam; massive; firm; contains small white specks, but no effervescence when tested with dilute hydrochloric acid; slightly acid.

The solum is about 35 to 50 inches thick. The A horizon is dark grayish brown, dark brown, or brown when plowed. The A2 horizon is usually incorporated into the plow layer. Reaction of the A horizon ranges from very strongly acid to medium acid. The B horizon is strong brown, yellowish brown, or dark yellowish brown. It is very strongly acid or strongly acid. In some profiles gray mottles are lacking in the B22t and B23t horizons. The C horizon is light clay loam, clay loam, or heavy loam. It ranges from slightly acid to mildly alkaline.

Lindley soils are near Hatton and Keswick, Mandeville, Menfro, Norris, and Winfield soils. Lindley soils have a lower clay content in the B horizon, and they lack the fragipan of Hatton soils. Lindley soils are better drained than Keswick soils.

LnE—Lindley loam, 14 to 30 percent slopes. This soil is on the side slopes of upland ridges. Areas are 5 to 600 acres or more in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are some small areas of moderately well drained Hatton silt loam, Keswick loam, and Gara loam. Also included are small areas where the slope is less than 14 percent or more than 30 percent. Hatton soils are on narrow, sharply rounded ridgetops. Keswick soils are on the upper parts of side slopes, and Gara soils are in small, narrow areas along the lower parts of side slopes. Small areas of shallow Norris silt loam and moderately deep Mandeville silt loam are also included in mapping. They are mostly on lower side slopes or in escarpment-like spots of deeply entrenched ravines and small streams. Moderately well drained Nodaway silt loam, well drained Napier silt loam, and poorly drained Bremer soils are on very narrow bottom lands 50 to 200 feet wide. These areas are dissected by many small, intermittent drainageways and streams.

Runoff is very rapid, and the hazard of erosion is severe to very severe. Because of its slope, extreme susceptibility to erosion, and medium natural fertility, this soil is not well suited to most farm uses. It is used mainly for woodland and, to a lesser extent, for pasture. Under good management, high quality forage plants can be established, and overgrazing can be prevented. Woodland management practices such as selective harvest cutting and the exclusion of grazing by livestock help to improve the existing stands of timber. The natural reproduction of the more desirable species such as white oak, black oak, red oak, ash, and walnut should be encouraged.

This soil has moderate to severe limitations for urban and recreational development. Suitability as habitat for open land wildlife is fair, and suitability as habitat for woodland wildlife is good. Capability unit VIe–4.

LrE3—Lindley clay loam, 14 to 30 percent slopes, severely eroded. This soil is on side slopes of upland ridges. Areas are 5 to 80 acres in size and are irregular in shape. This soil has a profile similar to that described as representative of the series, but erosion has largely removed the original loam surface layer. The present surface layer consists mainly of material from the clay loam subsoil.

Included with this soil in mapping are small areas of shallow Norris silt loam and moderately deep Mandeville silt loam and small areas of moderately well drained Winfield silt loam and well drained Menfro silt loam. Also included are moderately well drained Keswick soils in severely eroded spots on the uppermost parts of side slopes, areas where the soil has slopes of less than 14 percent, and spots where the soil still has a loam surface layer.

Runoff is very rapid, and the hazard of erosion is very severe. This soil is not suited to crops. Most areas are either in pasture or in the brush stage of reforestation. Establishment of high quality forage for pasture and prevention of overgrazing are serious concerns. Protection from grazing livestock is important in areas where woodland is being reestablished. Reproduction of such species as white oak, red oak, black oak, ash, and walnut should be encouraged.

This soil is better suited to pasture or woodland than to other uses. It has moderate to severe limitations for urban and recreational developments. Suitability as habitat for open land wildlife is fair, and suitability as habitat for woodland wildlife is good. Capability unit VIIe–7.

LsC—Lindley and Keswick loams, 5 to 9 percent slopes. These soils are on the narrow tops and side slopes of upland ridges. Areas are about 5 to 160 acres in size and are irregular in shape. These soils generally occur together. Most mapped areas contain both soils, but some areas are entirely one or the other.

The Lindley soil makes up about 60 percent of the total acreage of this mapping unit, and the Keswick soil makes up about 40 percent. The Lindley soil is on middle and lower parts of side slopes, and the Keswick soils have profiles similar to those described as representative of their series, but in many cultivated areas the surface layer is dark grayish brown or brown loam about 7 inches thick.

Included with these soils in mapping are small areas of moderately well drained Hatton, Weller, and Winfield silt loams. These soils generally are on ridgetops adjoining upper parts of side slopes and are inclusions in areas of the Keswick soil. Also included are some small areas of the moderately well drained Gara and Armstrong loams and small areas of soils that have slightly steeper slopes and have been eroded to such an extent that the plow layer is clay loam or clay.

Runoff is medium, and the hazard of erosion is moderate to severe. The control of erosion and the improvement of tilth and fertility are the main concerns of management. These soils are not well suited to intensive cropping. When cultivated, however, diversions, terraces, grassed waterways, minimum tillage, stripcropping, contour farming, cover crops, cropping sequences that include small grains, and long term grass-legume hay crops help to control erosion. Green manure crops and the return of crop residues help to build up the organic matter content and maintain tilth. Pastured areas need good management to establish high quality forage and prevent overgrazing. Woodlands should be managed to improve existing stands by using selective harvest cutting methods and excluding livestock. Cutting operations should favor natural reproduction of species such as white oak, red oak, black oak, ash, and walnut.

These soils are suited to limited cropping, but they are better suited to permanent hay or pasture. They have slight to severe limitations for urban and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–4.

LsD—Lindley and Keswick loams, 9 to 14 percent slopes. These soils are on side slopes of upland ridges. Areas are about 5 to 200 acres in size and irregular in shape. These soils generally occur together. Most mapped areas contain both soils, but some areas are entirely one or the other.

Lindley soil generally makes up about 70 percent of an area, and Keswick soil makes up about 30 percent. Lindley soil is on the middle and lower parts of side slopes, and Keswick soil is on the uppermost parts of side slopes. In some areas only one soil is present. The Lindley soil has a profile similar to that described as representative of the series, but in cultivated areas it has a brown loam surface layer about 5 to 7 inches thick. The Keswick soil has the profile described as representative of the series.

Included with these soils in mapping are small areas of moderately well drained Hatton silt loam. Also, some small areas of shallow Norris silt loam and moderately deep Mandeville silt loam are on the lower parts of side slopes or in escarpmentlike spots along deeply entrenched drainageways. Small areas where the soil is eroded and the surface layer is clay loam or clay are also included.

Runoff is rapid, and the hazard of erosion is severe to very severe. The control of erosion and the improvement and maintenance of tilth and fertility are the main concerns of management. When cropped, a sequence that includes small grains and long term grass and legume hay crops are needed to control erosion. Diversions, contour farming, grassed waterways, stripcropping, and cover crops benefit some areas. Return of crop residue helps build up the organic matter content. Pasture or permanent hay is a better use, however, for many areas of these soils. Good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. Such woodland management practices as selective harvest cutting methods and the exclusion of livestock from wooded areas helps improve existing stands. Cutting operations need to favor natural reproduction of species such as white oak, red oak, black oak, ash, and walnut.

These soils are not well suited to cropping. They are better suited to permanent hay or pasture. They have moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IVe–4.

LwD3—Lindley and Keswick clay loams, 9 to 14 percent slopes, severely eroded. These soils are on side slopes of upland ridges. Areas are about 7 to 150 acres in size and are irregular in shape. These soils generally occur together. Most mapped areas contain both soils, but some areas are entirely one or the other.

Lindley soil commonly makes up about 70 percent of an area, and Keswick soil makes up about 30 percent. The Lindley soil is on the middle and lower parts of side slopes, and the Keswick soil is on the uppermost parts of side slopes. These soils have profiles similar to those described as representative of their respective series, except that erosion has largely removed the original loam surface layer. As a result the present surface layer is mainly material from the upper part of the subsoil.

Included with these soils in mapping are small areas of moderately well drained Hatton silt loam and Winfield silt loam. Also included are some small areas of shallow Norris silt loam and moderately deep Mandeville silt loam on lower parts of side slopes or in escarpmentlike spots along deeply entrenched drainageways and ravines.

Runoff is very rapid, and the hazard of erosion is very severe. Most areas are not suited to cropping, and permanent hay or pasture are good farm uses. Good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. Protection from livestock is needed in areas that are becoming wooded once again. Species such as white oak, red oak, black oak, ash, and walnut should be favored.

These soils are better suited to permanent hay, pasture or woodland than to other uses. They have moderate to severe limitations for urban and recreational developments. Suitability as habitat for open land and woodland species of wildlife is good. Capability unit VIe–7.

Mandeville Series

The Mandeville series consists of moderately deep, well drained, moderately sloping to steep soils on uplands. These soils formed in residuum weathered from silty and clayey shale. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark brown silt loam about 5 inches thick. The subsurface layer is brown silt loam about 3 inches thick. The upper part of the subsoil is dark yellowish brown, friable heavy silt loam. The middle part is dark yellowish brown, firm silty clay loam and yellowish brown, firm silty clay loam. The lower part is brown, firm silty clay loam that has yellowish brown mottles. It is underlain by light olive brown, soft, weathered silty and clayey shale at a depth of about 35 inches.

Permeability and available water capacity are moderate. The shrink-swell potential of the subsoil is low.

Most areas of these soils are used for pasture or hay, or they remain wooded. These soils have low natural fertility. A few areas of the less sloping soils are planted to corn, soybeans, and small grains.

Representative profile of Mandeville silt loam, 9 to 14 percent slopes, in pasture about 2,100 feet east and 470 feet south of the northwest corner of sec. 32, T. 52 N., R. 15 W.:

A1—0 to 5 inches; dark brown (10YR 4/3) silt loam; strong fine granular structure; very friable; slightly acid; clear smooth boundary.

A2—5 to 8 inches; brown (10YR 5/3) silt loam; moderate fine granular structure; very friable; slightly acid; clear smooth boundary.

B1—8 to 11 inches; dark yellowish brown (10YR 4/4) heavy silt loam; moderate coarse granular structure; friable; common fine weathered shale fragments; medium acid; clear smooth boundary.

B21t—11 to 19 inches; dark yellowish brown (10YR 4/4) silty clay loam; moderate; very fine subangular blocky structure; firm; common medium weathered shale fragments; medium acid; gradual smooth boundary.

B22t—19 to 26 inches; yellowish brown (10YR 5/4) silty clay loam; moderate fine subangular blocky structure; firm; thin patchy dark brown clay films on ped faces; common weathered shale fragments; strongly acid; gradual smooth boundary.

B3—26 to 35 inches; brown (10YR 5/3) silty clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm; many weathered shale fragments that have dark streaks and stains of iron and manganese oxides on surfaces; strongly acid; clear wavy boundary.

Cr—35 to 60 inches; light olive brown (2.5Y 5/3) soft weathered silty and clayey shale that can easily be dug with a hand spade.

The solum ranges from about 21 to 45 inches in thickness. Where these soils are plowed, the A2 horizon is mixed into a dark brown, brown, or yellowish brown plow layer about 6 to 8 inches thick. The B1 horizon is brown, dark brown, or dark yellowish brown heavy silt loam or loam. It is strongly acid or medium acid in reaction. The B2t horizon is dark yellowish brown, yellowish brown, brown, or dark brown heavy silt loam or light silty clay loam. It is very strongly acid or strongly acid. The B3 horizon is yellowish brown or brown heavy silt loam, heavy loam, light silty clay loam, or light clay loam. It ranges from very strongly acid to medium acid. The C horizon is soft, and it generally can be easily dug with a hand spade. In some profiles, however, thin to moderately thick layers of limestone are at a depth of 5 feet or more.

These soils contain more clay in the B and C horizons than is within the defined range for the series, but this difference does not alter their usefulness and behavior.

Mandeville soils are near Lindley, Keswick, and Norris soils. Mandeville soils formed in residuum weathered from shale, and they lack the deep, thicker subsoil and loamy underlying material of the Lindley and Keswick soils that formed in glacial till. They are not so wet as Keswick soils and have a lower clay content in the subsoil. Mandeville soils are slightly deeper and have a thicker, finer textured subsoil than Norris soils.

MaC—Mandeville silt loam, 5 to 9 percent slopes. This soil is on the rounded tops and sides of upland ridges. Areas of this soil are irregularly shaped and range from about 5 to 120 acres in size.

Included with this soil in mapping are a few small areas of shallow Norris silt loam and small outcrops of the interbedded layers of limestone. The Norris soils are mostly on the higher part of the ridgetops or at the pointlike ends of ridges, and the outcrops of the interbedded limestone usually are along the lower or outer edges of these areas. Some small areas of moderately well drained Weller silt loam and poorly drained Marion silt loam are included where these areas border the flatter parts of wide ridgetops. Also included are a few small spots of Lindley and Keswick soils that are on the higher parts of narrow ridgetops or side slopes.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving tilth and fertility. Most areas of this soil are not well suited to intensive cropping because of the irregular shape of the areas and the complex slopes. Where they are cultivated, conservation cropping sequences that include long term grass and legume hay provide the best control of erosion. Minimum tillage, stripcropping, contour farming, and use of cover crops also help to prevent erosion. Return of crop residue to the soil and use of green manure crops help to build up the organic matter content.

This soil is suited to crops, but most areas are better used for permanent hay or pasture. Good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. Areas of this soil have slight to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–4.

MaD—Mandeville silt loam, 9 to 14 percent slopes. This soil is on side slopes of upland ridges. Areas of this soil are irregularly shaped, and they range from 5 to 200 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of shallow Norris silt loam and small outcrops of the interbedded layers of limestone. Also included are small areas of Lindley and Keswick soils on upper parts of side slopes.

Runoff is rapid and the hazard of erosion is severe. This soil is not suited to crops, but it is suited to permanent hay, pasture, or woodland. Good management is needed to establish and maintain high quality forage or grass and legume hay and to prevent overgrazing or excessive cutting. Woodland management practices, including selective harvest cutting and the exclusion of grazing by livestock, help to improve the existing stand of timber. The natural reproduction of such trees as white oak, red oak, black oak, ash, and walnut should be encouraged.

This soil has slight to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IVe–4.

MaE—Mandeville silt loam, 14 to 30 percent slopes. This soil is on the sides of upland ridges. Areas are irregularly shaped and range from about 8 to 100 acres in size.

Included with this soil in mapping are small areas of the shallow Norris silt loam and small outcrops of the interbedded layers of limestone. Also included are small spots of Lindley and Keswick soils on the higher parts of side slopes or on narrow ridgetops.

Runoff is very rapid, and the hazard of erosion is severe to very severe. This soil is not suited to crops, but it is suited to pasture or woodland. Good management is needed to establish and maintain high quality forage and prevent overgrazing. Woodland management practices, including selective harvest cutting and the exclusion of livestock, help to improve the existing stands of timber. Natural reproduction of tree species such as white oak, red oak, black oak, ash, and walnut is encouraged.

This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land wildlife is fair, and suitability as habitat for woodland wildlife is good. Capability unit VIe–7.

MbD3—Mandeville silty clay loam, 9 to 14 percent slopes, severely eroded. This soil is on sides of upland ridges. Areas are irregularly shaped and range from about 10 to 50 acres in size. This soil has a profile similar to that described as representative of the series. The silt loam surface layer has been eroded away, however, and the present plow layer is the former upper part of the subsoil.

Included with this soil in mapping are a few small areas of shallow Norris silt loam and small outcrops of the interbedded layers of limestone. Also included are small areas of Lindley and Keswick soils that are on the upper parts of the side slopes.

Runoff is rapid to very rapid, and the hazard of erosion is very severe. This soil is not suited to crops and is better used for permanent hay or pasture. Good management is needed to establish high quality forage or grass and legume hay and to prevent overgrazing or excessive cutting.

This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit VIe–7.

Marion Series

The Marion series consists of deep, poorly drained, nearly level soils on uplands. These soils formed in moderately thick deposits of loess. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark grayish brown silt loam about 5 inches thick. The subsurface layer is light brownish gray silt loam about 9 inches thick. The upper part of the subsoil is yellowish brown, very firm silty clay with grayish brown and red mottles. The middle part is mottled, grayish brown and yellowish brown, very firm silty clay. The lower part, to a depth of 60 inches, is light grayish brown, firm silty clay loam with yellowish brown mottles.

Permeability is very slow, and available water capacity is high. A seasonal high water table is present in winter and in spring. The shrink-swell potential of the subsoil is high.

Many areas of these soils are cultivated and planted mainly to corn, soybeans, small grains, and hay. These soils have medium natural fertility. Some areas are in pasture and others remain wooded.

Representative profile of Marion silt loam in an idle area about 300 feet west and 500 feet south of the center of sec. 14, T. 51 N., R. 15 W.:

A1—0 to 5 inches; dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable; very strongly acid; abrupt smooth boundary.

A2—5 to 14 inches; light brownish gray (10YR 6/2) silt loam; weak thin platy structure; very friable; many fine concretions of iron and manganese oxides; very strongly acid; clear smooth boundary.

B21t—14 to 19 inches; yellowish brown (10YR 5/4) silty clay; common fine distinct red (2.5YR 4/6) and grayish brown (10YR 5/2) mottles; moderate fine subangular blocky structure; very firm; thin silt coatings on vertical ped faces and along cracks; many fine concretions of iron and manganese oxides; very strongly acid; clear smooth boundary.

B22t—19 to 33 inches; mottled grayish brown (10YR 5/2) and yellowish brown (10YR 5/4) silty clay; moderate fine angular blocky structure; very firm; sticky when wet; very strongly acid; clear smooth boundary.

B3—33 to 60 inches; light grayish brown (10YR 6/2) silty clay loam; many medium distinct yellowish brown (10YR 5/6) mottles; weak fine subangular blocky structure; firm, compact and slightly brittle when moist; strongly acid.

The solum ranges from about 45 to 60 inches or more in thickness. In plowed areas the A1 and A2 horizons are mixed to form a dark grayish brown, dark brown, or brown layer about 7 to 9 inches thick. This layer ranges from very strongly acid to slightly acid in reaction depending on local practices of liming. The B21t horizon is yellowish brown, brown, or pale brown. Clay content increases abruptly between the A2 and the B2 horizons by at least 20 percent or more (absolute). The B2 horizon is very strongly acid or strongly acid. The B3 horizon ranges from very strongly acid to medium acid. It becomes less acid with depth.

These soils have grayer color in the B horizon than is defined in the range for the series, but this difference does not alter their usefulness and behavior.

Marion soils are near Hatton, Ladoga, Pershing, and Weller soils. They are more poorly drained, have a more abrupt increase in the clay content between the A and B horizons, and have a higher total amount of clay in the upper part of the subsoil than all of these soils.

Mc—Marion silt loam. This nearly level soil is on the flat parts of wider ridgetops in the uplands. Areas of this soil are irregularly shaped and range from about 7 to 150 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few areas of moderately well drained Weller silt loam and well drained, moderately deep Mandeville silt loam. These included soils are on convex slopes along the outer edges of areas of this nearly level Marion soil. Also included are some small spots of moderately well drained Hatton silt loam and Keswick loam.

Runoff is slow, and the hazard of erosion is slight. The main management concerns are removing excess water and improving tilth and fertility. Good systems to remove excess water are difficult to establish because of the irregular shapes of the areas and their nearly level to flat ridgetop positions with erodible adjoining soils on side slopes. Land smoothing or soil shaping combined with field ditches helps remove surface water in some areas. Grassed waterways and erosion control structures can be used to provide safe outlets. Minimum tillage and the return of crop residue to the soil help to improve the tilth. Timing plowing and planting operations to concur with optimum soil moisture conditions is extremely important.

This soil is suited to crops where excess water is removed. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. Some perennial plants such as alfalfa are not well suited to this soil because of its wetness and heaving. Compaction by livestock is a concern during periods of wetness. This soil has severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is fair. Capability unit IIIw-2.

Marshall Series

The Marshall series consists of deep, well drained, gently sloping to moderately sloping soils in uplands. These soils formed in deep deposits of loess. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish brown and about 13 inches thick. The upper part of the subsoil is dark brown, friable silt loam. The lower part is dark yellowish brown, firm silty clay loam. It is underlain at a depth of about 35 inches by yellowish brown and pale brown, friable silt loam.

Permeability is moderate, and available water capacity is high. The shrink-swell potential is moderate.

Most areas of these soils are cultivated. The main crops are corn, soybeans, small grains, and grass and legume hay.

These soils have high natural fertility. Some small patches of tobacco are grown in areas where the soils are less sloping. A few areas are in pasture, and a few scattered stands of trees have grown up in drainageways and in areas of eroded soils.

Representative profile of Marshall silt loam, 5 to 9 percent slopes, in a pasture about 400 feet south and 700 feet west of the northeast corner of sec. 16, R. 51 N., R. 17 W.:

A1—0 to 13 inches; very dark grayish brown (10YR 3/2) silt loam; strong fine granular structure; very friable; slightly acid; clear smooth boundary.

B1—13 to 21 inches; dark brown (10YR 3/3) silt loam; moderate very fine subangular blocky structure; friable; some ped faces have very dark brown (10YR 2/2) coatings; slightly acid; clear smooth boundary.

B2t—21 to 35 inches; dark yellowish brown (10YR 4/4) light silty clay loam; moderate medium subangular blocky structure; firm; some ped faces have very dark grayish brown (10YR 3/2) coatings; slightly acid; gradual smooth boundary.

C1—35 to 58 inches; yellowish brown (10YR 5/4) silt loam; common fine distinct yellowish brown (10YR 5/8) and light brownish gray (2.5Y 6/2) mottles; weak coarse subangular blocky structure; friable; slightly acid; diffuse wavy boundary.

C2—58 to 60 inches; pale brown (10YR 6/3) silt loam; massive; friable; some yellowish brown (10YR 5/6) stains; slightly acid.

The solum ranges from about 33 to 50 inches or more in thickness. The A horizon is very dark grayish brown, very dark brown, or, in places, dark brown. It ranges from medium acid to neutral in reaction, depending on local practices of liming. The B1 horizon is dark brown or brown silt loam or light silty clay loam. The B2t is dark yellowish brown, dark brown, or brown light silty clay loam or medium silty clay loam. Some profiles have a B3 horizon that is yellowish brown light silty clay loam or heavy silt loam about 6 to 25 inches thick. It is slightly acid. The C horizon is yellowish brown, pale brown, or light yellowish brown. It commonly has streaks, stains, and mottles of grayer or stronger yellowish brown colors. It is slightly acid or neutral.

Marshall soils are near Knox, Menfro, Sharpsburg, and Winfield soils. They have a thicker dark surface layer than all of these soils. Marshall soils are not so wet as Sharpsburg and Winfield soils, and they lack the gray color in the lower part of the subsoil that is characteristic of those soils.

MhB—Marshall silt loam, 2 to 5 percent slopes. This soil is on the tops of upland ridges. Areas are irregularly shaped and range from about 7 to 300 acres in size.

Included with this soil in mapping are a few areas where slopes are more than 5 percent and a few areas where the dark surface layer is less than 10 inches thick. Also included are small areas of moderately well drained Sharpsburg silt loam and well drained Knox silt loam.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion and maintaining tilth and fertility. Terrace systems, stripcropping, contour farming, cropping sequences, minimum tillage, cover crops, and grassed waterways help to control erosion. Return of crop residue to the soil and addition of plant nutrients and lime according to results of soil tests help to maintain the tilth and fertility.

This soil is well suited to intensive cropping if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to moderate limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–1.

MhC—Marshall silt loam, 5 to 9 percent slopes. This soil is on the tops and upper parts of side slopes of upland ridges. Areas are irregularly shaped and range from about 10 to 350 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of well drained Knox silt loam and Menfro silt loam. Also included are small areas of moderately well drained Sharpsburg silt loam. Some areas have small spots where the dark surface layer has been eroded away and the lighter colored subsoil is exposed.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and maintaining tilth and fertility. Terrace systems, grassed waterways, stripcropping, contour farming, minimum tillage, conservation crop sequences, and cover crops help to control erosion. Return of crop residue to the soil helps to maintain the tilth and fertility.

This soil is well suited to crops if erosion is controlled. Many areas are in pasture, and good management of the pasture is needed to establish high quality forage and prevent overgrazing. This soil has slight to moderate limitations for urban uses and recreational development. Suitability as a source of habitat for open land and woodland wildlife is good. Capability unit IIIe–1.

McGirk Series

The McGirk series consists of deep, somewhat poorly drained, moderately sloping soils on uplands. These soils formed in erosional sediment from adjacent and slightly higher loessial and residual soils. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark brown silt loam about 7 inches thick. The subsurface layer is grayish brown silt loam about 8 inches thick. The subsoil is firm silty clay loam about 45 inches thick. The upper part is grayish brown and has yellowish brown mottles, and the middle part is gray and has dark reddish brown stains. The lower part is light brownish gray and has yellowish brown mottles and dark reddish brown stains.

Permeability is slow, and available water capacity is high. A seasonal high water table is present in winter and spring. The shrink-swell potential of the subsoil is moderate to high.

Most areas of this soil are cultivated. The main crops are corn, soybeans, small grains, and hay. These soils have medium natural fertility. Some areas are used for pasture, and a few areas remain wooded.

Representative profile of McGirk silt loam, 5 to 12 percent slopes, in a pasture field about 700 feet west of the center of sec. 22, T. 49 N., R. 16 W.:

A1—0 to 7 inches; dark brown (10YR 4/3) silt loam; strong fine granular structure; very friable; strongly acid; clear smooth boundary.

A2—7 to 15 inches; grayish brown (10YR 5/2) silt loam; moderate fine granular structure; very friable; few fine concretions of iron and manganese oxides; strongly acid; clear smooth boundary.

B21tg—15 to 20 inches; grayish brown (10YR 5/2) silty clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; moderate fine granular structure; firm; many fine concretions of iron and manganese oxides; very strongly acid; clear smooth boundary.

B22t—20 to 32 inches; gray (10YR 5/1) heavy silty clay loam; strong medium subangular blocky structure; firm; many dark reddish brown stains and dark concretions of iron and manganese oxides; very strongly acid; gradual smooth boundary.

B3—32 to 60 inches; light brownish gray (2.5Y 6/2) silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure; firm; many dark reddish brown stains and concretions of iron and manganese oxides; very strongly acid.

The solum ranges from about 40 to 60 inches or more in thickness. In cultivated areas the A horizon has a dark brown, dark grayish brown, or brown plow layer about 7 to 9 inches thick. It ranges from strongly acid to medium acid in reaction, depending on local practices of liming. The B2t horizon is silty clay loam or light silty clay and is strongly acid or very strongly acid.

These soils contain less clay in the B horizon than is defined in the range for the series, but this difference does not alter their usefulness and behavior.

McGirk soils are near Lindley, Keswick, Menfro, Norris, and Winfield soils. They are wetter and have a grayer subsoil than all of these soils. The McGirk soils are deeper than Norris soils, and they lack the underlying weathered shale at a depth of 20 inches or less of the Norris soils.

MkC—McGirk silt loam, 5 to 12 percent slopes. This soil is on lower parts of side slopes, on concave toe slopes, in depressions at the upper ends of drainageways, and in saddlelike positions of the upland ridges. Areas of this soil are irregularly shaped and are about 2 to 150 acres in size.

Included with this soil in mapping are small, narrow areas of moderately well drained Winfield silt loam and Ladoga silt loam that are on upper parts of side slopes along the uppermost boundaries of the McGirk soils. Also included are a few small areas of moderately well drained Gara loam and Lindley loam. These soils on the upper parts of side slopes occur as narrow bands or spots above the McGirk soil.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are removing excess water, controlling erosion, and improving tilth and fertility. Diversion terraces and grassed waterways help to remove excess surface water and control erosion. Tile drainage that removes internal water and seepage is helpful in some areas. Cropping sequences, contour farming, minimum tillage, and cover crops help to control erosion. Also, the return of crop residue to the soil and use of green manure plants help to build up the organic matter content and maintain good tilth.

The soil is suited to limited crops if excess water is removed and erosion is controlled. Many areas of this soil are used for permanent hay or pasture. Good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. Compaction by livestock is a concern during wet periods. Some perennial plants such as alfalfa are not well suited to this soil because of wetness and heaving. This soil has severe limitations for urban uses and moderate to severe limitations for recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–2.

Menfro Series

The Menfro series consists of deep, well drained, gently sloping to steep soils on uplands. These soils formed in thick deposits of loess. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark grayish brown silt loam about 6 inches thick. The subsurface layer is dark brown silt loam about 4 inches thick. The upper part of the subsoil is dark brown, friable silt loam. The two middle parts are dark brown, firm silty clay loam, and the lower part is dark yellowish brown, friable light silty clay loam. This is underlain, at a depth of about 46 inches, by yellowish brown, friable light silty clay loam.

Permeability is moderate, and available water capacity is high. The shrink-swell potential of the subsoil is moderate.

The more gently and moderately sloping areas are cultivated and mainly planted to corn, soybeans, small grains, and grass and legume hay. These soils have high natural fertility. Steeper areas are used mostly for pasture and hay. Some areas remain wooded.

Representative profile of Menfro silt loam, 5 to 9 percent slopes, in a wooded area about 2,000 feet north and 1,000 feet east of the southwest corner of sec. 7, T. 49 N., R. 17 W.:

Ap—0 to 6 inches; dark grayish brown (10YR 4/2) silt loam, weak fine granular structure; very friable; neutral; abrupt smooth boundary.

A2—6 to 10 inches; dark brown (10YR 4/3) silt loam; weak fine granular structure; very friable; neutral; clear smooth boundary.

B1—10 to 12 inches; dark brown (7.5YR 4/4) silt loam; moderate medium and fine subangular blocky structure; friable; few faint gray silt coatings on some vertical ped surfaces; spotty clay films in pores and channels; slightly acid; clear smooth boundary.

B21t—12 to 19 inches; dark brown (7.5YR 4/4) silty clay loam; moderate medium subangular blocky structure; continuous clay films on ped faces; firm; medium acid; clear smooth boundary.

B22t—19 to 30 inches; dark brown (7.5YR 4/4) silty clay loam; strong medium subangular blocky structure; firm; continuous clay films on ped faces; medium acid; clear smooth boundary.

B3—30 to 46 inches; dark yellowish brown (10YR 4/4) light silty clay loam; weak medium subangular blocky structure; friable; medium acid; smooth gradual boundary.

C—46 to 60 inches; yellowish brown (10YR 5/4) light silty clay loam; weak medium subangular blocky structure; friable; medium acid.

The solum ranges from about 40 to 60 inches or more in thickness. The Ap horizon is dark grayish brown, dark brown, or brown. It ranges from medium acid to neutral in reaction, depending on local practices of liming. The B1 horizon is dark brown or dark yellowish brown silt loam or light silty clay loam. It ranges from strongly acid to neutral. The B2t horizon ranges from strongly acid to slightly acid. The B3 horizon is dark yellowish brown or dark brown and ranges from strongly acid to slightly acid. The C horizon is yellowish brown or dark brown silt loam, heavy silt loam, or light silty clay loam. It ranges from medium acid to neutral and typically becomes less acid with depth.

The Menfro soils are near the Knox, Lindley, Marshall, Norris, and Winfield soils. They lack the dark surface layer of the Knox and Marshall soils and have a lower content of fine sand or coarser material throughout the profile than the Lindley soils. Menfro soils are deep, and they lack the underlying weathered shale at a depth of less than 20 inches of the Norris soils.

MnB—Menfro silt loam, 2 to 5 percent slopes. This soil is on narrow tops of upland ridges. Areas of this soil are irregularly shaped but generally are longer than they are wide and range from about 3 to 110 acres in size.

Included with this soil in mapping are a few small areas where slopes are more than 5 percent. Also included are small areas of well drained Marshall silt loam and soils that have a dark colored surface layer less than 10 inches thick. A few small areas of moderately well drained Weller and Winfield silt loam soils are included in mapping.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion and improving and maintaining tilth and fertility. Because this soil is on narrow ridgetops and areas have irregular shapes, erosion control measures such as terrace systems and grassed waterways are commonly designed and installed to protect the steeper adjoining soils. Conservation cropping sequences, contour farming, minimum tillage, and cover crops help to control erosion. The return of crop residue and green manure crops to the soil helps to build up the organic matter content and maintain good tilth.

This soil is well suited to crops if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to moderate limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–1.

MnC—Menfro silt loam, 5 to 9 percent slopes. This soil is on the tops and upper parts of sides of upland ridges. Areas of this soil are irregularly shaped but generally are longer than they are wide. They range from about 3 acres to 400 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas where slopes are less than 5 percent and more than 9 percent. In areas where slope is more than 9 percent, the surface layer is generally thinner, and in many places the plow layer is the former upper part of the subsoil. Also included are small areas of moderately well drained Weller and Winfield silt loam and somewhat poorly drained McGirk silt loam. In places small areas of well drained Lindley loam and moderately well drained Keswick loam are included. They are in small spots and narrow bands along the lower boundaries of areas of this soil.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving tilth and fertility. Terraces, grassed waterways, contour farming, conservation cropping sequences, stripcropping, minimum tillage, and cover crops help to control erosion. Because of the irregular shape of the areas and the narrow ridgetop positions, some areas of this soil are not suited to terraces or to systems of terraces and grassed waterways. The return to the soil of crop residue and the use of green manure crops help build up the organic matter content and maintain good tilth.

This soil is suited to crops if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to moderate limitations for urban uses or recreational developments. Suitability as habitat for open land or woodland wildlife is good. Capability unit IIIe–1.

MnD—Menfro silt loam, 9 to 14 percent slopes. This soil is on the sides of upland ridges. Areas are irregularly shaped and range from about 3 to 100 acres in size.

Included with this soil in mapping are a few small areas where slopes are less than 9 percent and more than 14 percent. Also included are small areas of shallow Norris silt loam and moderately deep Mandeville silt loam. Along the lower parts of side slopes are small areas of well drained Lindley soils and moderately well drained Keswick soils. Some small areas of moderately well drained Winfield silt loam are also included.

Runoff is rapid, and the hazard of erosion is moderate to very severe. The main concerns of management are controlling erosion and improving fertility. Contour farming, stripcropping, conservation cropping sequences, grassed waterways, and cover crops help to control erosion. Areas of this soil are suited to cropping sequences that have two or more years of hay or permanent hay.

This soil is suited to limited cultivation if erosion is controlled. Many areas are used for pasture and permanent hay, and good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–1.

MnD3—Menfro silt loam, 9 to 14 percent slopes, severely eroded. This soil is on sides of upland ridges. Areas of this soil are irregularly shaped and range from about 2 to 120 acres in size. This soil has a profile similar to that described as representative of the series, but the surface layer has been eroded away, and the plow layer is now in the former upper part of the subsoil.

Included with this soil in mapping are small areas where slopes are less than 9 percent and more than 14 percent. Also included are small areas of well drained Lindley loam and moderately well drained Keswick loam. They are in small spots and narrow bands along the lower boundaries of areas of this soil. Some small areas of moderately well drained Winfield soils are included.

Runoff is rapid, and the hazard of erosion is very severe. This soil is suitable for permanent hay pasture or woodland. Good management is needed to establish high quality forage and hay crops and to prevent overgrazing and excessive cutting. In many places areas are growing up to brush and reverting to woodland. Natural reproduction of tree species such as white oak, black oak, red oak, ash, and walnut should be encouraged.

This soil is not suited to crops other than to permanent hay. It has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IVe–4.

MnE—Menfro silt loam, 14 to 30 percent slopes. This soil is on sides of upland ridges. Areas of this soil are irregularly shaped and range from about 4 to 400 acres in size.

Included with this soil in mapping are small areas of shallow Norris silt loam and moderately deep Mandeville silt loam. Also included are small areas of well drained Lindley loam and moderately well drained Keswick loam. Some small narrow bands of somewhat poorly drained McGirk silt loam are included along the lower boundaries of areas of this soil.

Runoff is very rapid, and the hazard of erosion is very severe. This soil is used for woodland. Existing stands can be improved by selective harvest cutting and the exclusion of livestock. Natural reproduction of tree species such as white oak, red oak, black oak, ash, and walnut is encouraged.

This soil is not suited to crops or pasture. It has severe limitations for urban uses and recreational development. Suitability as habitat for open land wildlife is fair, and suitability as habitat for woodland wildlife is good. Capability unit VIe–1.

Mexico Series

The Mexico series consists of deep, somewhat poorly drained, gently sloping soils on uplands. These soils formed in moderately thick deposits of loess on old glacial till. The native vegetation is prairie grasses and deciduous trees.

In a representative profile the surface layer is very dark grayish brown silt loam about 8 inches thick. The subsurface layer is grayish brown silt loam about 7 inches thick. The upper part of the subsoil is dark grayish brown, firm clay that has yellowish brown mottles. The middle part is grayish brown, firm clay that has yellowish brown and yellowish red mottles. The lower part, to a depth of 38 inches, is mottled, grayish brown and yellowish brown, firm silty clay. It is underlain by grayish brown, firm silty clay loam that has yellowish brown mottles.

Permeability is very slow, and available water capacity is moderate. A seasonal high water table is present in winter and in spring. The shrink-swell potential of the subsoil is high to very high.

Most areas of these soils are cultivated and planted mainly to corn, soybeans, small grains, and hay. These soils have medium natural fertility. Some areas are used for pasture, and a few areas are wooded.

Representative profile of Mexico silt loam, 2 to 5 percent slopes, in a cultivated field about 2,000 feet east of the northwest corner of sec. 3, T. 50 N., R. 14 W.:

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) silt loam; moderate fine granular structure; very friable; many fine dark concretions of iron and manganese oxides; strongly acid; clear smooth boundary.

A2—8 to 15 inches; grayish brown (10YR 5/2) silt loam; moderate fine granular structure; very friable; many fine dark concretions of iron and manganese oxides; strongly acid; clear smooth boundary.

B21t—15 to 20 inches; dark grayish brown (10YR 4/2) clay; common fine distinct yellowish brown (10YR 5/6) mottles; strong fine subangular blocky structure; firm; many fine dark concretions of iron and manganese oxides; very strongly acid; gradual smooth boundary.

B22t—20 to 29 inches; grayish brown (10YR 5/2) clay; many coarse prominent yellowish brown (10YR 5/6) and yellowish red (5YR 4/6) mottles; moderate medium subangular blocky structure; firm; few fine dark concretions of iron and manganese oxides; very strongly acid; gradual smooth boundary.

B3—29 to 38 inches; mottled grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/6) silty clay; weak medium subangular blocky structure; firm; many fine dark concretions of iron and manganese oxides; strongly acid; gradual smooth boundary.

C—38 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam; many fine distinct yellowish brown (10YR 5/6) mottles; weak coarse subangular blocky structure; firm; many iron and manganese stains; slightly sticky; slightly acid.

The solum ranges from about 30 to 50 inches in thickness. Depth to the underlying glacial till is typically more than 50 inches. The Ap horizon is very dark grayish brown or very dark brown. It ranges from strongly acid to slightly acid in reaction, depending on local practices of liming. An A2 horizon is not in some profiles. The B21t horizon typically is dark grayish brown. It has few to many yellowish brown, grayish brown, or gray mottles, and in some profiles there are red or yellowish red mottles. The B21t horizon is silty clay loam, light silty clay, or clay. It is very strongly acid or strongly acid. The B22t horizon is silty clay or silty clay loam that is very strongly acid or strongly acid. The B3 horizon is silty clay or silty clay loam that is strongly acid or medium acid. The C horizon ranges from strongly acid to slightly acid. In some profiles there is a IIC horizon of mottled, grayish brown and yellowish brown or gray and strong brown silty clay loam or clay loam. This horizon contains few to common coarse sand grains or fine pebbles. Typically it is medium acid to neutral.

These soils have a more abrupt increase in the clay content between the A2 and B2t horizon than is defined in the range for the series, but this difference does not alter their usefulness and behavior.

The Mexico soils are near Armstrong, Gara, Hatton, Keswick, Lindley, and Weller soils. They are more poorly drained, and are grayer in the upper part of the subsoil than all of these soils. Mexico soils have less fine sand and coarser material in the upper 40 inches of the solum than Armstrong, Gara, Keswick, and Lindley soils. They lack the fragipan of the Hatton soils.

MoB—Mexico silt loam, 2 to 5 percent slopes. This soil is on high upland divides and wide, gently undulating ridgetops. Areas of this soil are irregularly shaped and range from about 7 to 120 acres in size.

Included with this soil in mapping are small areas of moderately well drained Gara and Armstrong loams in spots and narrow bands along the outer edges of the mapped areas. Also included are a few small areas of the well drained Lindley loam and moderately well drained Keswick loam. In some small depressions are areas of poorly drained soils that have profiles similar to those of Mexico soils.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are removing excess water, controlling erosion, and improving tilth and fertility. The use of terraces, diversions, underground outlets, and grassed waterways help in the removal of excess surface water and the control of erosion. Contour farming, minimum tillage practices, conservation cropping sequences, and use of cover crops also help to control erosion. The return of crop residue to the soil and the use of green manure crops help to improve tilth. Timing plowing, planting, and harvesting operations to concur with optimum soil moisture condition is extremely helpful in maintaining good tilth.

This soil is suited to intensive cropping if the excess water is removed and erosion is controlled. Areas used for pasture need good management in order to establish high quality forage and prevent overgrazing. Excessive compaction of the soil by livestock during periods of wetness is a concern. This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–5.

Moniteau Series

The Moniteau series consists of deep, poorly drained, level to nearly level soils on second bottoms and terraces of the major creeks and small streams. These soils formed in the silty alluvial sediment derived from the nearby uplands. The native vegetation is deciduous trees and wetland shrubs.

In a representative profile the surface layer is dark grayish brown silt loam about 7 inches thick. The subsurface layer is light brownish gray silt loam about 7 inches thick. The upper part of the subsoil is light brownish gray, firm silty clay loam that has yellowish brown and dark gray mottles. The middle part is gray, very firm silty clay loam that has yellowish brown mottles. The lower part is gray, firm light silty clay loam that has yellowish brown and dark brown mottles. It is underlain, at a depth of 67 inches, by gray, firm heavy silt loam that has yellowish brown and dark brown mottles.

Permeability is slow, and available water capacity is high. A seasonal high water table is present in winter and in spring. The shrink-swell potential of the subsoil is moderate. These soils are subject to flooding of short duration.

Many areas of these soils are cultivated and mainly planted to corn, soybeans, small grains, and hay. These soils have medium natural fertility. Some areas are in pasture, and a few areas remain wooded.

Representative profile of Moniteau silt loam in a cultivated field about 1,300 feet north and 375 feet west of the southeast corner of sec. 19, T. 51 N., R. 15 W.:

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam; very weak thin platy structure parting to weak fine granular; friable; many fine roots in upper 3 inches, common roots in lower part; few very fine round concretions; slightly acid; clear smooth boundary.

A2—7 to 14 inches; light brownish gray (10YR 6/2) silt loam; white (10YR 8/2) dry; common fine distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) mottles; moderate medium platy structure parting to weak very fine subangular blocky structure; friable; common vesicular pores; common fine roots; common concretions up to 4 millimeters in diameter; common root channels; medium acid; clear smooth boundary.

B1tg—14 to 18 inches; light brownish gray

(10YR 6/2) medium silty clay loam; common fine distinct yellowish brown (10YR 5/4) and few fine distinct dark gray (10YR 4/1) mottles; moderate fine and medium angular blocky structure; firm; few fine roots; common pores; common root channels lined with clay films; common fine concretions and soft bodies of iron and manganese oxides; strongly acid; clear smooth boundary.

B21tg—18 to 27 inches; gray (10YR 5/1) and 6/1) silty clay loam; common fine prominent yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; very firm; few fine roots; few fine pores; few root channels lined with thick clay films; thin patchy clay films on ped faces; common soft dark bodies of iron and manganese oxides; very strongly acid; gradual smooth boundary.

B22tg—27 to 42 inches; gray (10YR 5/1) and 6/1) silty clay loam; common fine prominent yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; very firm; few fine roots; few fine pores; few root channels lined with thick clay films; thin patchy clay films on ped faces; common soft dark bodies of iron and manganese oxides; very strongly acid; gradual smooth boundary.

B3tg—42 to 67 inches; gray (2.5Y 5/1) light silty clay loam; many fine prominent yellowish brown (10YR 5/6) and dark brown (10YR 4/4) mottles; very weak medium prismatic structure parting to very weak fine subangular blocky structure; firm; few fine roots; few fine pores; few root channels lined with clay films; thin, patchy clay films on vertical ped faces; common dark soft bodies of iron and manganese oxides; strongly acid; gradual smooth boundary.

Cg—67 to 87 inches; gray (2.5Y 5/1) heavy silt loam; many fine prominent dark brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles and few fine faint gray (N 5) mottles; massive; firm; very few fine roots; few root channels lined with thin clay films; common pockets of soft dark bodies of iron and manganese oxides; medium acid.

The solum ranges from 36 to 70 inches or more in thickness. The Ap horizon is typically dark grayish brown or dark gray. It ranges from very strongly acid to slightly acid in reaction, depending on local practices of liming. The B horizon is typically gray or grayish brown and has yellowish brown and dark gray mottles. It ranges from very strongly acid to medium acid. The C horizon is heavy silt loam or light silty clay loam. It ranges from very strongly acid to medium acid.

Moniteau soils are near Bremer, Carlow, Fatima, Freeburg, and Nodaway soils. They contain less clay in their subsoil than Bremer and Carlow soils, and their surface layer is lighter colored and contains less organic matter. Moniteau soils are more poorly drained and have a grayer subsoil and a lighter colored surface layer than the Fatima and Nodaway soils. They are more poorly drained and contain a slightly higher content of clay and grayer color in the subsoil than the Freeburg soils.

Mu—Moniteau silt loam. This level to nearly level soil is on the low terraces and second bottoms of the small and secondary streams in the uplands. Areas range from small and rounded to long and narrow or large and irregular in shape. They range from about 2 to 80 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few small areas of moderately well drained Fatima silt loam and somewhat poorly drained Freeburg silt loam. Also included are small areas of poorly drained Bremer silt loam and Carlow silty clay.

Runoff is slow, and the hazard of erosion is none to slight. The main concerns of management are removing excess water, improving tilth and fertility, and the possibility of short duration floods. Excess surface water can be removed by using systems of land shaping, field ditches, and (in some places) diversions to cut off surface water flow from nearby uplands. Return of crop residue to the soil and use of green manure crops help to improve the tilth. The flooding problems of this soil are generally minor, and most floods occur late in winter and early in spring prior to cropping seasons. Flood protection measures are usually not practical or economically feasible to install and maintain.

This soil is suited to crops, and many areas are used for permanent hay and pasture. Good management is needed to establish high quality forage or hay crops and prevent overgrazing or excessive cutting. This soil has severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is fair. Capability unit IIIw-2.

Napier Series

The Napier series consists of deep, well drained, gently sloping soils on terracelike positions along the narrow valleys of small streams. These soils formed in alluvial sediment derived from the surrounding loess covered uplands. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark grayish brown silt loam about 12 inches thick. The subsoil is very dark grayish brown, friable silt loam about 34 inches thick. It is underlain by dark brown silt loam at a depth of about 46 inches.

Permeability is moderate, and available water capacity is very high. These soils are subject to very brief flooding.

Many areas of these soils are too small or inaccessible for intensive crops. Cultivated areas are planted mainly to corn and soybeans. These soils have high natural fertility. Most areas are used for pasture or remain in an idle state. A few areas have a sparse cover of trees and shrubs.

Representative profile of Napier silt loam, 2 to 5 percent slopes, in a cultivated field about 300 feet south of Greggs Creek and 150 feet northeast of Highway 87 in survey 2456, T. 51 N., R. 17 W.:

A1—0 to 12 inches; very dark grayish brown (10YR 3/2) silt loam; moderate fine granular structure; friable; neutral; clear smooth boundary.

B1—12 to 22 inches; very dark grayish brown (10YR 3/2) silt loam; moderate fine subangular blocky structure; friable; coatings of very dark brown (10YR 2/2) on faces of peds; neutral; gradual smooth boundary.

B2—22 to 46 inches; very dark grayish brown (10YR 3/2) silt loam; moderate medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

C—46 to 60 inches; dark brown (10YR 3/3) silt loam; weak medium subangular blocky structure; friable; slightly acid.

The solum ranges from 36 to about 55 inches in thickness. The A horizon is very dark grayish brown, very dark brown, or black. It is slightly acid or neutral in reaction. The B horizon is very dark grayish brown or dark brown and is slightly acid or neutral. The C horizon is dark brown or brown and ranges from slightly acid to mildly alkaline.

These soils are darker colored to a greater depth than is defined in the range for the series, but this difference does not alter their usefulness and behavior.

Napier soils are near Carlow, Knox, and Nodaway soils. They are not so wet as Carlow soils and have less clay in the subsoil. Napier soils have a thicker, darker colored surface layer and subsoil than Knox and Nodaway soils, and their surface layer and subsoil contain more organic matter. Napier soils are not so wet as Nodaway soils.

NaB—Napier silt loam, 2 to 5 percent slopes. This soil is on concave foot slopes, alluvial fans, and low terracelike positions at the base of valley side slopes along narrow-bottomed streams. Areas of this soil are generally long and narrow or irregular in shape. They range from about 10 to 140 acres in size.

Included with this soil in mapping are a few small areas of poorly drained Bremer silt loam and Carlow silty clay. Also included are small areas of well drained Nodaway and Haynie silt loams. In places small areas of more strongly sloping Knox silt loam are included.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion and improving fertility. Because of size, shape, and position in the landscape, most of these areas are farmed with larger areas of other soils or, because of inaccessibility are used only for pasture or woodland. Erosion can be controlled by terraces or diversions in some places, but most areas of this soil are not suited to these protective measures. Conservation cropping sequences, contour farming, stripcropping, minimum tillage, and use of cover crops are methods of erosion control that can be applied to these areas. Some areas have become wooded, and this soil has good potential for black walnut timber and nut production.

This soil is well suited to crops, but many areas are used for permanent hay and pasture. Good management is needed to establish high quality forage or hay crops and to prevent overgrazing and excessive cutting. This soil has slight to moderate limitations for urban uses or recreational development. Suitability as habitat for open land wildlife is fair, and suitability as habitat for woodland wildlife is good. Capability unit IIe-1.

Nodaway Series

The Nodaway series consists of deep, moderately well drained, nearly level soils. They are on first bottoms of small streams, major creeks, and deltalike areas at the outlets and along the valley bluffs where the smaller tributary flood plains join the Missouri River botton land. These soils formed in silty alluvial sediment derived from the soils of the surrounding uplands. The native vegetation is grasses, shrubs, and trees.

In a representative profile the surface layer is a dark brown silt loam about 8 inches thick. It is underlain, to a depth of 41 inches, by stratified brown and dark grayish brown, friable silt loam that has dark grayish brown and dark gray mottles. Between depths of 41 and 60 inches is very dark gray, firm silty clay.

Permeability is moderate to a depth of 41 inches and very slow at a depth below 41 inches. Available water capacity is high. These soils are subject to flooding of brief duration. The shrink-swell potential of the underlying material is moderate to high.

The larger areas are cultivated or used for hay and pasture. These soils have high natural fertility, and where cropped they are mainly planted to corn or soybeans. The smaller, inaccessible, or long and narrow areas that are subject to frequent flash flooding are used mostly for pasture or remain idle.

Representative profile of Nodaway silt loam in a cultivated field about 4,600 feet south and 800 feet west of the northeast corner of sec. 25, T. 49 N., R. 16 W.:

Ap—0 to 8 inches; dark brown (10YR 4/3) silt loam; moderate medium granular structure; friable; neutral; abrupt smooth boundary.

C1—8 to 16 inches; brown (10YR 5/3) silt loam; few faint dark grayish brown (10YR 4/2) mottles; moderate medium granular structure; friable; neutral; diffuse smooth boundary.

C2—16 to 41 inches; dark grayish brown (10YR 4/2) silt loam; few fine faint dark gray (10YR 4/1) mottles; weak medium subangular blocky structure; friable; slightly acid; diffuse smooth boundary.

IIC3—41 to 60 inches; very dark gray (10YR 3/1) silty clay; weak medium subangular blocky structure; firm; slightly acid.

The Ap horizon is dark brown, very dark grayish brown, or very dark brown. It is slightly acid or neutral in reaction. The C horizon is stratified. The strata are brown, dark brown, dark grayish brown, and grayish brown. They have yellowish brown, grayish brown, light brownish gray, gray, and dark gray mottles. The C horizon is dominantly silt loam in the upper 40 inches and has thin strata of silty clay loam and very fine sandy loam. Below a depth of 40 inches, thin to thick strata of silty clay, silty clay loam, silt loam, and very fine sandy loam occur within short horizontal and vertical distances. The C horizon ranges from medium acid to neutral.

These soils have a lighter colored Ap horizon and a higher clay content at a depth below 40 inches than is given in the defined range for the series, but these differences do not alter their usefulness and behavior.

Nodaway soils are near Bremer, Carlow, Fatima, Freeburg, and Moniteau soils. They are not so wet as Bremer and Carlow soils, and their surface layer is not so thick and dark as the one in those soils. Also the clay content in the upper 40 inches of the profile is lower in Nodaway soils than it is in Bremer and Carlow soils. Nodaway soils have a thinner, lighter colored surface layer than Fatima soils. They have a lower clay content in the upper 40 inches than the Freeburg and Moniteau soils, and they are not so wet as those soils.

Nd—Nodaway silt loam. This nearly level soil is on the first bottom of the small streams in the uplands and along the bluffs and deltas where the secondary streams join the bottom lands of the Missouri River. Areas are long and narrow and follow the irregular meanders of the stream channels. They range from about 10 to 1,000 acres or more in size but typically occur in areas 1/4 mile or less in width. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of poorly drained Bremer silt loam and Carlow silty clay soils that are in small, isolated depressions and long, narrow sloughs of old abandoned stream channels. Also included are small areas of well drained Fatima soil loam and Haynie silt loam. A few small areas of somewhat poorly drained Freeburg silt loam and poorly drained Moniteau silt loam are in small spots and narrow bands along the outer edges of areas of this soil next to the valley side slopes.

Runoff is slow, and the hazard of erosion is none to slight. The main concern of management is flooding. Most areas of this soil are too narrow or too poorly located for major flood protection measures such as levees, dikes, and the like. Where this soil is farmed, it is benefited by the addition of fertilizer according to soil tests.

This soil is well suited to crops in areas where flooding is infrequent. Local records and local persons should be consulted about areas most subject to flooding. Selecting crops that can be grown and harvested during periods of low flow will help reduce losses caused by flooding. Many areas are used for pasture, and some areas are wooded. Woodland species such as black walnut have a good potential for timber and nut production on these soils. This soil has severe limitations for urban uses and recreational development. Suitability as habitat for wildlife is good. Capability unit IIw–1.

Norris Series

The Norris series consists of shallow, well drained, strongly sloping to steep soils on uplands. These soils formed in residuum weathered from soft shale. The native vegetation is deciduous trees.

In a representative profile the surface layer is very dark grayish brown silt loam about 3 inches thick. The subsoil is yellowish brown, friable silt loam about 10 inches thick. It is underlain by light olive brown, yellowish brown, and olive silty clay loam lenses that are interbedded with thin layers of soft, brown, dark brown, and olive shale.

Permeability is moderate, and available water capacity is very low. The shrink-swell potential of this soil is low, and the underlying shale is rippable by light excavating equipment to a depth of several feet.

For the most part these soils are used for pasture or are wooded. They have low natural fertility and are not suited to cultivated crops or hay. These soils produce a thin, poor stand of low quality timber.

Representative profile of Norris silt loam in a wooded area of Norris-Rock land complex, 10 to 30 percent slopes, 1,250 feet east and 2,700 feet south of the northwest corner of sec. 33, T. 51 N., R. 14 W.:

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

B2—3 to 13 inches; yellowish brown (10YR 5/4) silt loam; moderate fine and medium subangular blocky structure; friable; 10 to 15 percent common fine soft shale fragments; very strongly acid; gradual smooth boundary.

Cr—13 to 60 inches; mixed light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/6) silty clay loam with lenses of olive (5Y 5/4) alternatingly interbedded with thin layers of soft shale; broken edges of the shale are brown, dark brown, and olive; easily dug with hand spade; very strongly acid.

The solum ranges from 8 to 20 inches in thickness. The depth to soft, weathered shale is the same as the thickness of the solum. The solum is strongly acid to very strongly acid in reaction throughout. The A1 horizon is very dark grayish brown or very dark gray loam or silt loam. The B horizon is yellowish brown, brown, or dark brown loam or silt loam. It is 10 to 35 percent soft to hard fragments of shale that are mostly 3 inches or less in length. About 1 to 2 percent of the fragments are commonly 3 to 10 inches long. The C horizon is soft, weathered shale that is rippable by light equipment to a depth of several feet. In places thin to moderately thick layers or ledges of hard limestone occur at a depth usually greater than 5 feet.

Norris soils are near Lindley, Keswick, Mandeville, and Menfro soils. They have a thinner solum and contain less clay in the subsoil than these soils. Norris soils are not so wet as Keswick soils.

NoE—Norris-Rock land complex, 10 to 30 percent slopes. This complex is on narrow ridgetops and steep side slopes of river bluffs and ridges in the uplands. Areas are irregularly shaped and range from about 5 to 200 acres in size.

Norris soils make up about 70 percent of this complex, and Rock land makes up about 30 percent. The shallow Norris soils formed in a discontinuous mantle of residuum weathered from soft shale. They have the profile described as representative of the series.

The Rock land areas in this complex range from small spots of exposed raw shale bedrock that is littered with many shale fragments and thin slablike pieces of interbedded limestone to larger areas of shale bedrock covered with a thin shaly silt loam mantle less than 10 inches thick (fig. 8). A few areas have exposures or outcroppings of the ledgelike interbedded limestone or the thick underlying limestone bedrock formations.

Included with this complex in mapping are small areas of moderately deep Mandeville silt loam. Also included are many small areas and spots where these soils are underlain directly by limestone bedrock. Many small clifflike or almost vertical escarpments are included, mostly on the river bluffs of the Missouri River Valley or along the narrow bottom lands of the deeply entrenched secondary streams in the uplands. A few areas have small narrow bands of well drained Lindley loams included along the upper parts of this complex. In places small areas of moderately well drained Gara loam and Winfield silt loam are included in mapping. These soils generally are above areas of the Norris-Rock land complex and are included as long

Figure 8.—Rock land area in the Norris-Rock land complex, 10 to 30 percent slopes.

narrow bands of soils along the upper parts of side slopes.

Runoff is rapid, and the hazard of erosion is severe. Areas of this complex are poorly suited to most farm uses because of their shallow depth to bedrock and their steepness of slope.

This complex is not suited to crops and is very limited in its use for pasture. It is better suited to woodland and as habitat for wildlife. Limitations for urban uses and recreational development range from moderate to severe. Suitability as habitat for open land and woodland wildlife is poor. Capability unit VIIe–8.

Pershing Series

The Pershing series consists of deep, somewhat poorly drained, gently sloping to moderately sloping soils on uplands. These soils formed in thick deposits of loess. The native vegetation is grasses and trees.

In a representative profile the surface layer is very dark grayish brown silt loam about 9 inches thick. The subsurface layer is dark grayish brown silt loam about 8 inches thick. The upper 3 inches of the subsoil is dark grayish brown, friable silty clay loam; the next 13 inches is dark brown, firm silty clay that has dark grayish brown and yellowish brown mottles; the next 16 inches is mottled, gray and yellowish brown, firm silty clay; and the next 11 inches is mottled, gray and yellowish brown, firm silty clay loam.

Permeability is slow, and available water capacity is high. A seasonal, perched water table is present late in winter and in spring. The shrink-swell potential of the subsoil is high.

In many areas these soils are cultivated and mainly planted to corn, soybeans, small grains, and hay. These soils have medium natural fertility. Some areas are used for pasture, and a few areas remain wooded.

Representative profile of Pershing silt loam, 2 to 5 percent slopes, in a cultivated field about 2,500 feet south and 100 feet east of the northwest corner of sec. 12, T. 50 N., R. 15 W.:

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) silt loam; moderate fine granular structure; very friable; medium acid; abrupt smooth boundary.

A2—9 to 17 inches; dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; very friable; medium acid; clear smooth boundary.

B1—17 to 20 inches; dark grayish brown (10YR 4/2) silty clay loam; grayish brown (10YR 5/2) ped faces; few fine yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; friable; many fine dark concretions of iron and manganese oxides; strongly acid; abrupt smooth boundary.

B21t—20 to 33 inches; dark brown (10YR 4/3) silty clay; faces of peds dark grayish brown (10YR 4/2); few fine yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure parting to moderate fine blocky; firm;

many fine dark concretions of iron and manganese oxide; medium acid; gradual smooth boundary.

B22t—33 to 49 inches; mottled gray (10YR 6/1) and yellowish brown (10YR 5/8) light silty clay; weak coarse subangular blocky structure; firm; thin discontinuous clay films on face of peds; many dark stains and fine concretions of iron and manganese oxides; medium acid; gradual smooth boundary.

B3—49 to 60 inches; mottled gray (10YR 6/1) and yellowish brown (10YR 5/8) silty clay loam; weak coarse subangular blocky structure; firm; many dark stains and fine concretions of iron and manganese oxides; medium acid.

The solum is typically 60 inches thick or more. The Ap horizon is very dark grayish brown or very dark gray and ranges from strongly acid to slightly acid in reaction, depending on local practices of liming. The B1 horizon is dark grayish brown or grayish brown and has yellowish brown, grayish brown, olive brown, or olive gray mottles. It is strongly acid or medium acid. The B21t horizon is dark brown and has grayish brown and yellowish brown mottles, or it is yellowish brown and grayish brown and is mottled. It is strongly acid or medium acid. The B22t horizon is light silty clay or heavy clay. It is strongly acid or medium acid. The B3 horizon is grayish brown and yellowish brown or gray and yellowish brown and is mottled. It is silty clay loam, light silty clay loam, or heavy silt loam that is strongly acid or medium acid.

Pershing soils are near Armstrong, Gara, Grundy, Ladoga, and Weller soils. They are more poorly drained and have a grayer subsoil than Armstrong, Gara, Ladoga, and Weller soils. Pershing soils have a thinner dark surface layer and contain less organic matter in the upper part of the subsoil than Grundy soils.

PrB—Pershing silt loam, 2 to 5 percent slopes. This soil is on broad, slightly rounded and narrow convex ridgetops and on the convex upper parts of side slopes in the uplands. Areas of this soil are long and narrow or are irregularly shaped. They range from about 5 to 350 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of moderately well drained Armstrong loam, Gara loam, Ladoga silt loam, and Weller silt loam. Armstrong and Gara soils generally occur as small narrow bands along the lower, outer borders of this Pershing soil, and Ladoga and Weller soils are at the same or higher elevations on ridgetops.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion, removing excess water, and improving tilth and fertility. Good systems that remove the excess water and provide protection from erosion are difficult to establish. In places diversions, shallow ditches, and grassed waterways can be used effectively to control runoff water and erosion. Conservation cropping sequences, stripcropping, contour farming, minimum tillage practices, and use of cover crops help prevent erosion and improve tilth. The return of crop residue to the soil helps build up and maintain the organic matter content and improve tilth.

This soil is suited to crops if the excess water is removed and erosion is controlled. Many areas are used for pasture, and good management is needed to establish high quality forage and prevent overgrazing. Timing plowing and planting operations to concur with optimum soil moisture conditions is extremely important. Some perennial plants such as alfalfa are not well suited to this soil because of wetness and heaving. Compaction by livestock is a concern during periods of wetness. This soil has moderate to severe limitations for urban uses and moderate limitations for recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–5.

PrC—Pershing silt loam, 5 to 9 percent slopes. This upland soil is on very narrow, convex upper parts and wider, concave lower parts of side slopes and at the heads or upper parts of draws and drainageways. Areas range from long and narrow to irregular in shape and from about 10 to 150 acres in size.

Included with this soil in mapping are small areas of moderately well drained Armstrong and Gara loams that occupy positions on side slopes below Pershing soils and are included as narrow bands or spots along their lower boundaries. Also included are some small areas of moderately well drained Ladoga and Sharpsburg silt loam soils that occupy positions as small spots and narrow bands along the upper parts of ridgetops and side slopes above Pershing soils.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion, removing excess water, and improving tilth and fertility. The use of terraces with systems of underground outlets, erosion control structures, and grassed waterways can in places help to remove the excess water and control erosion. Conservation cropping sequences, stripcropping, contour farming, minimum tillage practices and use of cover crops also help to control erosion. Return of crop residue to the soil helps maintain and improve tilth.

This soil is suited to crops if the excess water is removed and erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. Timing plowing and planting operations to concur with optimum soil moisture conditions is extremely important. Some perennial plants such as alfalfa are not well suited to this soil because of its wetness and heaving. Compaction by livestock is a concern during periods of wetness. This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–5.

Riverwash

Rw—Riverwash. These miscellaneous areas consist of sand and gravel bars recently deposited at the edges of the active channel of the Missouri River. They are barren in most places or sparsely covered with willow and cottonwood saplings. Slopes are 0 to 2 percent. Because of their position next to the continually rising and falling river and long narrow shape of its areas, these areas have little or no potential for farm, urban, or recreational uses. They are important locally, however, as a source of sand and gravel for road building and other engineering purposes. They have some potential for wildlife habitat and nesting ground for waterfowl and birds. Areas of Riverwash are subject to frequent flooding and deposition and to constant changes of size, shape, and position. During periods of violent floods or turbulent high water these areas can be completely removed. Capability unit VIIIs–1.

Sarpy Series

The Sarpy series consists of deep, excessively drained, level to nearly level soils on the flood plain of the Missouri River. These soils formed in sandy alluvial sediment. The native vegetation is a thin stand of grasses, sandburs, and deciduous trees.

In a representative profile the surface layer is dark grayish brown sand about 11 inches thick. It is underlain by grayish brown, loose sand to a depth of 6 inches or more.

Permeability is very rapid and available water capacity is low. Sarpy soils are subject to flooding.

Some areas of these soils are cropped to corn, soybeans, and small grains, mainly as inclusions in large field layouts involving other more fertile and less droughty soils. A few areas are idle; others remain wooded.

Representative profile of Sarpy sand in an idle area about 500 feet west and 400 feet north of the southeast corner of sec. 22, T. 50 N., R. 18 W.:

Ap—0 to 11 inches; dark grayish brown (10YR 4/2) sand; single grained; loose; mildly alkaline; slight effervescence; clear smooth boundary.

C—11 to 60 inches; grayish brown (10YR 5/2) sand; single grained; loose; mildly alkaline; slight effervescence.

The A horizon is very dark grayish brown or dark brown where plowed. It ranges to dark brown, very dark gray, or very dark grayish brown and is less than 5 inches thick. The A horizon is neutral or mildly alkaline in reaction. The C horizon is grayish brown, brown, or yellowish brown. It is predominantly mildly alkaline.

Sarpy soils are near Haynie, Hodge, and Leta soils. They contain considerably less silt and clay than Haynie and Leta soils, and they are not so wet as Leta soils. Sarpy soils contain slightly less silt and clay than Hodge soils, and they lack the thin bands or lenses that are characteristic of some of the Hodge soils.

Sa—Sarpy sand. This level to nearly level soil is on the bottom lands of the Missouri River. It usually is near or next to the active river channel or the recently abandoned meanders. Areas of this soil vary in shape from long and narrow to wide and irregular and range from about 3 to 200 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are a few small areas of well drained Hodge loamy fine sand and areas where recent, stratified silty sediment has been deposited on this soil by floodwater. In a few areas of this soil, free carbonates have been leached to a depth of more than 10 inches.

Runoff is slow, and the hazard of erosion is very slight. The main concerns of management are building up the organic matter content, improving fertility, and preventing soil blowing. Use of green manure crops and the return of crop residue to the soil help to increase the organic matter content. The addition of plant nutrients according to soil tests and crop needs is very important. Use of irrigation and sprinkler type irrigation systems are beneficial to vegetables or other high value specialty crops.

This soil is not well suited to most crops or to pasture. It has some potential for specialized cropping if extremely careful management, including irrigation, is used. Some kind of vegetative cover needs to be maintained on all unused or idle areas to prevent soil blowing and possible damage to adjacent soils or crops. This soil has moderate to severe limitations for urban uses and recreational development, depending on the amount of protection against flooding. Suitability as habitat for open land or woodland wildlife is poor. Capability unit IVs–1.

Sharpsburg Series

The Sharpsburg series consists of deep, moderately well drained, gently sloping to moderately sloping soils on uplands. These soils formed in moderately thick deposits of loess. The native vegetation is tall prairie grasses.

In a representative profile the surface layer is very dark brown silt loam about 11 inches thick. The upper 5 inches of the subsoil is very dark brown, friable silt loam; the next 8 inches is very dark grayish brown, firm silty clay loam; the next 7 inches is dark brown, firm silty clay loam; and the next 7 inches is dark brown, firm silty clay loam that has dark grayish brown, yellowish brown, and light olive brown mottles. It is underlain by grayish brown, friable silt loam that has yellowish brown and light olive brown mottles.

Permeability is moderately slow, and available water capacity is high. The shrink-swell potential of the subsoil is high.

Most areas of these soils are cultivated and mainly planted to corn, soybeans, small grains, and grass and legume hay. These soils have high natural fertility. Some areas are used for pasture, and a few areas have a sparse cover of trees.

Representative profile of Sharpsburg silt loam, 2 to 5 percent slopes, in a cultivated field about 400 feet east and 50 feet south of the northwest corner of sec. 13, T. 52 N., R. 17 W.:

A1—0 to 11 inches; very dark brown (10YR 2/2) silt loam; strong medium granular structure; friable; medium acid; abrupt smooth boundary.

B1—11 to 16 inches; very dark brown (10YR 2/2) silt loam; strong fine subangular blocky structure; friable; medium acid; clear smooth boundary.

B21t—16 to 24 inches; very dark grayish brown (10YR 3/2) silty clay loam; strong medium subangular blocky structure; firm;

thin continuous clay films on ped faces; medium acid; gradual smooth boundary.

B22t—24 to 31 inches; dark brown (10YR 4/3) silty clay loam; moderate medium subangular blocky structure; firm; few fine concretions and stains of iron and manganese oxides; medium acid; gradual smooth boundary.

B3—31 to 38 inches; dark brown (10YR 4/3) silty clay loam; common fine distinct dark grayish brown (10YR 4/2), light olive brown (2.5Y 5/4), and yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; firm; medium acid; diffuse smooth boundary.

C—38 to 56 inches; grayish brown (2.5Y 5/2) silt loam; common medium and fine distinct yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/4) mottles; weak medium subangular blocky structure; friable; dark stains and concretions of iron and manganese oxides; slightly acid.

The solum ranges from about 35 to 50 inches in thickness. The Ap horizon is very dark brown or very dark grayish brown. It ranges from strongly acid to slightly acid in reaction, depending on local practices of liming. The B1 horizon is very dark brown or very dark grayish brown silt loam or light silty clay loam. It is strongly acid to slightly acid. The B2t horizon is very dark grayish brown, dark brown, or brown. It is strongly acid or medium acid. The C horizon is light silty clay loam or silt loam.

These soils have darker colors in the upper part of the subsoil and have a thinner solum than is defined in the range for the series, but these differences do not alter their usefulness and behavior.

Sharpsburg soils are near the Edina, Greenton, Grundy, Marshall, and Weller soils. They are not so wet and have less gray color in the upper part of the subsoil than Edina and Grundy soils. Sharpsburg soils lack the underlying residuum weathered from shale at a depth of 42 inches that is characteristic of Greenton soils. They are more poorly drained and are grayer in the lower part of the subsoil than Marshall soils. Sharpsburg soils have a thicker, darker surface layer and are darker in the upper part of the subsoil than Weller soils.

ShB—Sharpsburg silt loam, 2 to 5 percent slopes. This soil is on high, narrow to moderately wide ridgetops of the uplands. The areas are generally longer than they are wide, but some of the areas are irregularly shaped. They range from about 5 to 300 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of moderately well drained Ladoga and Winfield silt loams and somewhat poorly drained Grundy silt loam.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion, maintaining tilth, and improving fertility. Erosion control measures such as diversions, terrace systems, and grassed waterways are generally not practical because of the narrow ridgetop positions and the irregular shapes of some of the areas. Most erosion control practices of this kind are applied to these areas only for the purpose of protecting the lower adjacent soils and steeper slopes. Conservation crop sequences, contour farming, stripcropping, minimum tillage, and cover crops help control erosion in these areas. The return of crop residue to the soil helps maintain tilth.

These soils are well suited to intensive cropping if the erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to severe limitations for urban uses and slight to moderate limitations for recreational projects. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIe–1.

ShC—Sharpsburg silt loam, 5 to 9 percent slopes. This soil is on side slopes of high ridges in the uplands. Areas of this soil are irregularly shaped and range from about 5 to 180 acres in size. This soil has a profile similar to that described as representative of the series, but in many places the silt loam upper layer of the subsoil has been mixed with the surface layer by plowing.

Included with this soil in mapping are small areas of somewhat poorly drained Grundy silt loam and poorly drained Bremer silt loam. These soils are below areas of the Sharpsburg soils. They occupy small spots and narrow bands where slopes are concave along the lower boundaries of this soil. Also included are a few small areas of moderately well drained Ladoga and Weller silt loams.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion, maintaining tilth, and improving fertility. Terrace systems, grassed waterways, contour farming, stripcropping, conservation cropping sequences, minimum tillage practices, and use of cover crops help to control erosion. Return of crop residue to the soil and use of green manure crops help to maintain the tilth.

This soil is suited to crops if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to severe limitations for urban uses and recreational development. Suitability as habitat for open land or woodland wildlife is good. Capability unit IIIe–1.

Weller Series

The Weller series consists of deep, moderately well drained, gently sloping to moderately sloping soils on uplands. These soils formed in thick deposits of loess. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark grayish brown silt loam about 7 inches thick. The subsurface layer is brown silt loam about 4 inches thick. The upper 5 inches of the subsoil is dark yellowish brown, firm silty clay loam; the next 7 inches is dark yellowish brown, very firm light silty clay that has yellowish brown and light brownish gray mottles; the next 11 inches is light brownish gray, firm silty clay that has yellowish brown mottles; and the remaining 37 inches is mottled, yellowish brown and light brownish gray, firm silty clay loam.

Permeability is slow, and available water capacity is high. A seasonal, perched water table is present late in winter and in spring. The shrink-swell potential of the subsoil is high.

In some areas these soils are cultivated. Corn, soybeans, small grains, and hay are the main crops. These soils have medium natural fertility. They are used mostly for pasture and hay. A few areas remain wooded.

Representative profile of Weller silt loam, 2 to 5 percent slopes, in pasture about 2,000 feet south and 400 feet east of the northwest corner of sec. 12, T. 49 N., R. 15 W.:

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam; moderate fine granular structure; friable; few fine concretions of iron and manganese oxides; medium acid; clear smooth boundary.

A2—7 to 11 inches; brown (10YR 5/3) silt loam; moderate fine granular structure; friable; few fine concretions of iron and manganese oxides; medium acid; clear smooth boundary.

B1—11 to 16 inches; dark yellowish brown (10YR 4/4) silty clay loam; moderate fine subangular blocky structure; firm; brown (10YR 5/3) silt coatings on ped faces; firm; common fine concretions of iron and manganese oxides; medium acid; clear smooth boundary.

B21t—16 to 23 inches; dark yellowish brown (10YR 4/4) light silty clay; few fine faint yellowish brown (10YR 5/6) and light brownish gray (10YR 6/2) mottles; moderate fine subangular blocky structure; very firm; light gray silty coatings and continuous brown clay films on ped faces; common fine concretions of iron and manganese oxides; very strongly acid; clear smooth boundary.

B22t—23 to 34 inches; light brownish gray (10YR 6/2) silty clay; common medium distinct yellowish brown (10YR 5/6) mottles; moderate medium and coarse subangular blocky structure; firm; thin continuous dark grayish brown clay films on ped faces; few fine concretions of iron and manganese oxides; very strongly acid; gradual smooth boundary.

B31t—34 to 56 inches; mottled yellowish brown (10YR 5/6) and light brownish gray (2.5Y 6/2) heavy silty clay loam; weak coarse subangular blocky structure; firm; few fine concretions of iron and manganese oxides; thin clay films on vertical ped faces; strongly acid; gradual smooth boundary.

B32t—56 to 71 inches; light brownish gray (2.5Y 6/2) silty clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak coarse subangular blocky structure; firm; few fine concretions of iron and manganese oxides; strongly acid.

The solum is typically more than 60 inches thick. The Ap horizon is very dark grayish brown or dark brown. It ranges from very strongly acid to slightly acid in reaction, depending on local practices of liming. The A2 horizon is brown or grayish brown and ranges from very strongly acid to medium acid. The B horizon is yellowish brown or dark yellowish brown. It has grayish brown or light brownish gray mottles 10 inches or less from the top of the horizon. It ranges from very strongly acid to medium acid and typically becomes less acid with depth.

Weller soils are near Armstrong, Gara, Ladoga, Marion, Pershing, and Sharpsburg soils. They formed in deep loess and contain less fine sand and coarser material than the Armstrong and Gara soils that formed in glacial till. Weller soils have a higher clay content in the subsoil, are slightly more poorly drained, and have a lighter colored surface layer than Ladoga soils. They are not so wet as Marion soils, and they lack the abrupt change in content of clay from the A horizon to the B horizon that is characteristic of Marion soils. Weller soils have a lighter colored surface layer than Pershing soils. They lack the dominantly gray colored subsoil of the Pershing soils and are not so wet as those soils.

WeB—Weller silt loam, 2 to 5 percent slopes. This soil is on high, slightly rounded ridgetops and pointlike ends of ridges in the uplands. Areas of this soil are generally long and narrow or irregularly shaped. They range from 5 to 140 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of moderately well drained Ladoga and Sharpsburg silt loams. Also included are small areas of poorly drained Marion silt loam that occupies flat spots in slight depressions on the wider ridgetops, and some small areas of somewhat poorly drained Pershing silt loam. The Pershing silt loam is typically in long, narrow, fingerlike ridgetop areas where this Weller silt loam joins wider, flatter areas of Pershing soils on the main parts of the ridgetops. In places small areas of well drained Lindley loam and moderately well drained Armstrong, Gara, and Keswick loam soils are included. These glacial till soils occupy side slopes below areas of Weller soils in small spots and narrow bands along the lower boundaries of this Weller soil.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion and improving the tilth and fertility. Erosion controls such as diversions, terrace systems, and grassed waterways are generally not practical because of the narrow ridgetop positions and irregular shapes of the areas. Most erosion controls of this kind are applied only to protect the lower adjacent soils and steeper slopes. Conservation cropping sequences, contour farming, stripcropping, minimum tillage practices, and use of cover crops are more effective erosion controls. The return of crop residue to the soil and the use of green manure crops help to improve tilth.

This soil is suited to crops if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to severe limitations for urban uses and slight to moderate limitations for recreational projects. Suitability as habitat for open land wildlife is good, and suitability as habitat for woodland wildlife is fair. Capability unit IIIe–5.

WeC—Weller silt loam, 5 to 9 percent slopes. This soil is on very narrow tops and sides of ridges in the uplands. Areas of this soil are irregularly shaped and range from about 3 to 230 acres in size.

Included with this soil in mapping are small areas of well drained Lindley loam and moderately well drained Armstrong, Gara, and Keswick loams. These glacial till soils are on side slopes below areas of Weller soils. They are in small spots and narrow bands along the lower boundaries of this soil. Also included are a few small areas of somewhat poorly drained Pershing silt loam. Along the upper parts of the side slopes and on the narrow ridgetops, small areas of moderately well drained Winfield and Ladoga silt loams are included. Where the lower boundaries of this soil border major drainageways and stream bottoms, a few small areas of poorly drained Bremer silt loam and moderately well drained Fatima silt loam are also included.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving the tilth and fertility. Terraces, diversions, grassed waterways, conservation cropping sequences, contour farming, stripcropping, minimum tillage, and cover crops help control erosion. The return of crop residue to the soil and use of green manure crops help to improve tilth.

This soil is suited to crops if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has slight to severe limitations for urban uses or recreational development. Suitability as habitat for open land or woodland wildlife is fair. Capability unit IIIe–5.

Winfield Series

The Winfield series consists of deep, moderately well drained, gently sloping to strongly sloping soils on uplands. These soils formed in thick deposits of loess. The native vegetation is deciduous trees.

In a representative profile the surface layer is dark grayish brown silt loam about 8 inches thick. The subsurface layer is brown silt loam about 5 inches thick. The upper 2 inches of the subsoil is dark brown, friable silt loam; the next 13 inches is dark brown, firm silty clay loam; the next 12 inches is dark yellowish brown, firm silty clay loam that has light brownish gray mottles; and the remaining 20 inches is mottled, light brownish gray and yellowish brown, friable heavy silt loam.

Permeability is moderate, and available water capacity is very high. A seasonal perched high water table is present in winter and in spring. The shrink-swell potential of the subsoil is moderate.

In many areas these soils are cultivated. Corn, soybeans, small grains, and grass and legume hay are the main crops. These soils have high natural fertility. Some areas are in pasture, and a few areas are wooded.

Representative profile of Winfield silt loam, 5 to 9 percent slopes, in a cultivated field about 500 feet east and 600 feet south of the northwest corner of sec. 12, T. 49 N., R. 17 W.:

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A2—8 to 13 inches; brown (10YR 5/3) silt loam; weak thin platy structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.

B1—13 to 15 inches; dark brown (10YR 4/3) heavy silt loam; moderate fine subangular blocky structure; friable; faint patches of clean silt coatings on vertical ped faces; medium acid; clear smooth boundary.

B21t—15 to 28 inches; dark brown (10YR 4/3) silty clay loam; strong fine and medium subangular blocky structure; firm; thin continuous clay films on ped faces; medium acid; gradual smooth boundary.

B22t—28 to 40 inches; dark yellowish brown (10YR 4/4) silty clay loam; common fine distinct light brownish gray (10YR 6/2) mottles; moderate coarse subangular blocky structure; firm; few discontinuous dark brown (10YR 4/3) clay films on ped faces; strongly acid; gradual smooth boundary.

B3tg—40 to 60 inches; mottled light brownish gray (10YR 6/2) yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4) heavy silt loam; weak medium prismatic structure parting to weak medium subangular blocky structure; friable; strongly acid.

The solum ranges from about 50 to 60 inches or more in thickness. The Ap horizon is dark grayish brown or dark brown and ranges from medium acid to neutral in reaction, depending on local practices of liming. The A2 horizon is brown, dark brown, or yellowish brown and is medium acid or slightly acid. The B1 horizon is dark brown, dark yellowish brown, or yellowish brown heavy silt loam or light silty clay loam. It ranges from very strongly acid to medium acid. The B21t horizon is dark brown or dark yellowish brown and ranges from very strongly acid to medium acid. The B22t horizon is dark yellowish brown or dark brown and has grayish brown or light brownish gray mottles, or it is variegated grayish brown, dark brown, and yellowish brown. It ranges from very strongly acid to medium acid. The B3t horizon is heavy silt loam or light silty clay loam that is strongly acid or medium acid.

Winfield soils are near Lindley, Keswick, Mandeville, Marshall, Menfro, and McGirk soils. They formed in deep loess and have a lower content of fine sand or coarser material than the Lindley and Keswick soils, which formed in glacial till. Winfield soils are deep and lack the underlying shale at a depth of 40 inches or less that is characteristic of Mandeville soils. They are more poorly drained than Marshall and Menfro soils, and they lack the thick, dark surface layer of Marshall soils. They are not so wet as McGirk soils, and they lack the predominantly gray colored subsoil of those soils.

WnB—Winfield silt loam, 2 to 5 percent slopes. This soil is on narrow tops or ridges and hills in the uplands. Areas are generally long and narrow or irregularly shaped. They range from about 5 to 160 acres in size.

Included with this soil in mapping are a few areas of somewhat poorly drained McGirk silt loam and moderately well drained Weller silt loam. Some small areas of moderately well drained Keswick loam and well drained Lindley loam are also included. These glacial till soils are on side slopes below areas of Winfield soils in small spots and narrow bands along the lower boundaries of this Winfield soil. In places small areas of well drained Menfro silt loam soils are included.

Runoff is medium, and the hazard of erosion is moderate. The main concerns of management are controlling erosion and improving the tilth and fertility. Because of the narrow ridgetop positions and irregular shapes of the areas, erosion control measures such as terrace systems and grassed waterways are usually designed and installed to protect the adjoining soils and slopes. Conservation cropping sequences, contour farming, minimum tillage practices, stripcropping, and use of cover crops are effective in the control of erosion. The return of crop residue to the soil and use of green manure crops helps to improve the tilth.

This soil is well suited to crops if erosion is controlled. Many areas are used for pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has moderate to severe limitations for urban uses and slight to moderate limitations for recreational projects. Suitability as a source of habitat for open land and woodland wildlife is good. Capability unit IIe–1.

WnC—Winfield silt loam, 5 to 9 percent slopes. This soil is on narrow ridgetops and upper parts of side slopes in the uplands. Areas of this soil are irregularly shaped and range from about 5 to 100 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of well drained Menfro silt loam and small areas of moderately well drained Weller silt loam. Included along the lower boundaries of this soil are small areas of somewhat poorly drained McGirk silt loam. Some small areas of well drained Lindley loam and moderately well drained Keswick loam are also included. They are on side slopes below areas of Winfield soil in small spots and narrow bands along the lower boundaries of this Winfield soil.

Runoff is medium, and the hazard of erosion is moderate to severe. The main concerns of management are controlling erosion and improving the tilth and fertility. Terrace systems, grassed waterways, diversions, conservation cropping sequences, stripcropping, contour farming, minimum tillage practices, and use of cover crops help to control erosion. Return of crop residue to the soil and use of green manure crops help to improve tilth.

This soil is suited to crops if erosion is controlled. Many areas are in pasture, and good management is needed to establish high quality forage and prevent overgrazing. This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–1.

WnD—Winfield silt loam, 9 to 14 percent slopes. This soil is on very narrow, knifelike ridgetops and on sides of ridges and hills in the uplands. Areas of this soil are irregularly shaped and range from about 5 to 100 acres in size.

Included with this soil in mapping are small areas of well drained Menfro silt loam. Also included are small areas of well drained Lindley loam and moderately well drained Keswick soils. In places small areas of shallow Norris silt loam and moderately deep Mandeville silt loam are included.

Runoff is rapid, and the hazard of erosion is severe to very severe. The main concerns of management are controlling erosion and improving tilth and fertility. In most areas the soil is too steep for installation of complete terrace systems, but in places diversions or single terraces are effective in controlling erosion. Use of small grains and hay in cropping sequences, contour farming, stripcropping, minimum tillage practices, and use of cover crops help to control erosion. Return of crop residue to the soil helps to improve tilth.

This soil has limited use for crops if erosion is controlled. Many areas are used for pasture and permanent grass and legume hay. Good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land and woodland wildlife is good. Capability unit IIIe–1.

WnD3—Winfield silt loam, 9 to 14 percent slopes, severely eroded. This soil is on sides of ridges in the uplands. Areas are irregularly shaped and range from about 3 to 200 acres in size. This soil has a profile similar to that described as representative of the series, but the plow layer is made up mostly of material from the lighter colored subsurface layer and subsoil. In many places the silty clay loam subsoil is exposed at the surface. Many areas are dissected by small, deep gullies or occasional large gullies that cannot be crossed by vehicles or farm equipment.

Included with this soil in mapping are small areas of shallow Norris silt loam and moderately deep Mandeville silt loam. Also included in places are small areas of somewhat poorly drained McGirk silt loam that generally are below areas of eroded Winfield soil in small spots and narrow bands along the lower boundaries of this Winfield soil.

Runoff is rapid, and the hazard of erosion is very severe. This soil is not well suited to crops, and the main concern of management is the prevention of further erosion and the reclamation of gullied areas. The use of diversions and grassed waterways helps to control erosion in some areas. The use of small grains and long term hay crops or permanent grass and legume hay in cropping sequences is an effective erosion control measure. Where it is feasible to use such practices, contour farming and stripcropping are helpful in controlling erosion. Return of crop residue to the soil helps to improve tilth.

This soil has limited suitability for crops if erosion is controlled. Many areas are used for pasture and permanent hay. Good management is needed to establish a high quality forage or hay crop and to prevent overgrazing or excessive cutting. This soil has moderate to severe limitations for urban uses and recreational development. Suitability as habitat for open land or woodland wildlife is good. Capability unit IVe-4.

Use and Management of the Soils

Basic practices used in the management of soils for crops and pasture are described in the first part of this section, and yields of principal field and pasture crops are then given. Management of the soils for woodland, wildlife habitat, and recreation are discussed next; then, in the latter part of the section, information on the use of the soils for engineering purposes is presented.

Cultivated Crops and Pasture

About one-half the area of Howard County is cultivated. Corn, soybeans, wheat, and hay are the principal crops. Grain sorghum is another important crop; also, small acreages of oats, tobacco, tree fruits, and potatoes are planted.

About 25 percent of the county is used for open pasture. Native bluegrass dominates most pastures, but there is a substantial and increasing acreage of improved pasture.

Control of water erosion on cropland is the overriding consideration in managing most of the upland soils in the survey area. In most areas sloping cropland has been damaged to some degree by sheet, rill, or gully erosion. In most places a combination of mechanical and vegetative practices are needed to control erosion. Exceptions to this are the nearly level upland soils, where wetness rather than erosion is the major management concern. Wetness is also a problem on some heavy textured soils that are on bottom land and need surface drainage.

Seeding and renovation of more pastures is another management concern in the county.

All of the soils need management that will help conserve water, maintain or increase the organic matter content and fertility level, and promote good tilth.

Good management increases yields and gives greater assurance of an adequate economic return. A conservation cropping system combines suitable crop rotations with needed management and conservation practices to prevent soil deterioration. Technical assistance in the planning and application of practices for a particular field or farm can be obtained from the Howard County Soil and Water Conservation District of the Soil Conservation Service.

The management practices needed for soils that are suitable for crops and pasture are briefly discussed in the following paragraphs. This discussion supplements the specific management practices given for each mapping unit.

High fertility levels increase the yields of grain and forage. Crop cover reduces the destructive impact of raindrops. Plant residue left on the surface helps to maintain the organic matter content and keep the soil porous, thereby increasing the water intake rate and the available water capacity. Plant residue left on or near the surface also retards runoff and helps to control erosion. Its effectiveness depends on the amount of residue and the length of time it is left on the surface. Thus, higher yields leave more residue, and corn will leave substantially more than a soybean crop of comparable yield. Spring plowing of sloping soils allows residue to remain on the surface over winter and is more effective than fall plowing, which leaves the surface bare. Tillage that leaves residue on the surface during the growing season is still more effective. Minimum tillage practices help to maintain good tilth, increase infiltration, and curtail erosion. The use of chisel plows, direct planting of conventionally plowed fields, and other special techniques reduce the amount of tillage. Currently, no till planters are gaining acceptance.

Soils on bottom lands or nearly level soils on uplands can be continuously intertilled without excessive erosion or reduced yields. Special management for intensive cropping generally includes maintaining fertility, managing crop residue, and using minimum tillage practices. Most soils on bottom lands and level or gently sloping soils on uplands are potentially suited to supplemental irrigation.

Field terraces reduce the length of slope and, together with contour tillage, are very effective erosion control measures on sloping cropland. A system in which terraces are nearly parallel to each other is much preferred, because it greatly reduces point rows and makes farming more convenient.

Properly located and constructed grassed waterways serve as outlets to terrace systems. These waterways are designed to be crossed by and convenient for large farming equipment.

Cross slope channels are used to reduce the length of very long, gentle slopes. These channels, except for a much wider horizontal spacing, are very similar to field terraces. Diversion terraces are designed and constructed to protect cultivated soils from water that runs off higher pasture or woodland.

Drainage ditches need suitable outlets which are available in most places. There are a few exceptions on the flood plains of the Missouri River and on some of the broader parts of the secondary stream bottoms.

Control of flooding on the flood plains of some streams in the survey area is feasible under existing conservation programs. One such program is Public Law 566 (Small Watershed Program).

Some bottom lands on the Missouri River flood plain are protected from flooding by levees. The great floods of 1951 and 1973 demonstrated that such protection can be inadequate.

Many good stands of high yielding grass and legume pastures have been established in the county, and more are needed.

The following combination of management practices will help to assure the establishment and maintenance of good pasture: plowing early in summer; applying lime and fertilizer according to soil tests; seeding a mixture of good, clean, adapted grasses and legumes; controlling weeds and brush; applying a topdress of fertilizer if needed and economically practical; and maintaining stand and the high plant vigor by periodically rotating pastures. Using pastures for a short period of intensive grazing followed by a longer period of rest is often desirable.

Good management of pastures can extend the grazing season considerably, but supplemental hay generally will be needed. The amount of hay needed will vary depending on the type of livestock enterprise, the forage species, the severity of the winter, and the amount and duration of snow cover.

Capability Grouping

Landowners, particularly those who farm on a large scale, may find it practical to use and manage alike some of the different kinds of soil they have on their farms. These persons can make good use of the capability classification system presented in this section, a grouping that shows, in a general way, the suitability of soils primarily for cultivated crop production.

The grouping is based on permanent limitations of soils when used for field crops, the risk of damage when they are farmed, and the way the soils 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 that require special management.

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

In the capability system, all kinds of soils are grouped at three levels: the class, the subclass, and the unit. The broadest grouping, the capability class, is designated by Roman numerals I to VIII. In class I are the soils that have the fewest limitations, the widest range of use, and the least risk of damage when they are tilled. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. The subclass indicates major kinds of limitations within the classes. Within most of the classes there can be up to 4 subclasses. The subclasses are indicated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIc. The letter "e" shows that the main limitation is risk of erosion unless close growing plant cover is maintained; "w" means 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" indicates 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 or no limitations. Class V can contain, at the most, only subclasses w, s, and c, because the soils are subject to little or no erosion but have other limitations that confine their use largely to pasture, range, or wildlife habitat.

Subclasses are further divided into groups called capability units. These are groups of soils that are so much alike that they are suited to the same crops and pasture plants, require about the same management, and have generally similar productivity and other response to management. Capability units are generally identified by numbers assigned locally, for example, IIw-2 or IIIe-5.

The eight classes in the capability system and the subclasses and units in Howard County are described in the list that follows. The unit designation is given in the Guide to Mapping Units.

Class I. Soils have few limitations that restrict their use. (No subclasses)

Unit I-1. Deep, nearly level, well drained soils with moderate permeability and high available water capacity; on bottom lands.

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

Subclass IIe. Soils subject to moderate erosion unless protected.

Unit IIe-1. Deep, gently sloping, moderately well drained and well drained soils with moderate to moderately slow permeability and high available water capacity; on uplands.

Unit IIe-4. Deep, gently sloping, moderately well drained soils with moderately slow to very slow permeability and moderate to high available water capacity; on uplands.

Unit IIe-5. Deep, gently sloping, moderately well drained and somewhat poorly drained soils with slow and very slow permeability and high or moderate available water capacity; on uplands.

Subclass IIw. Soils moderately limited because of excess water.

Unit IIw-1. Deep, nearly level, moderately well drained and somewhat poorly drained soils with moderate or moderately slow permeability and high or very high available water capacity; on bottom lands.

Unit IIw-2. Deep, nearly level, poorly drained and somewhat poorly drained soils with slow to very slow permeability and moderate or high available water capacity; on bottom lands, terraces, or uplands.

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

Subclass IIIe. Soils subject to severe erosion if they are cultivated and not protected.

Unit IIIe-1. Deep, moderately sloping to strongly sloping, well drained and moderately well drained soils with moderate to slow permeability and moderate to high available water capacity; on uplands.

Unit IIIe-2. Deep, moderately sloping, somewhat poorly drained soils with slow permeability and high available water capacity; on uplands.

Unit IIIe-4. Deep to moderately deep, moderately sloping, well drained soils with very slow to moderate permeability and moderate available water capacity; on uplands.

Unit IIIe-5. Deep, gently sloping and moderately sloping, moderately well drained and somewhat poorly drained soils with slow permeability and moderate to high available water capacity, on uplands.

Subclass IIIw. Soils severely limited for cultivation by excess water.

Unit IIIw–2. Deep, nearly level, poorly drained soils with slow and very slow permeability and high available water capacity; on uplands and terraces.

Unit IIIw–4. Deep, nearly level or depressional, poorly drained soils with very slow permeability and moderate available water capacity; on bottom lands.

Subclass IIIs. Soils severely limited because of droughtiness, stony surfaces, or both.

Unit IIIs–1. Deep, nearly level, well drained soils with rapid permeability and low available water capacity; on bottom lands.

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

Subclass IVe. Soils subject to very severe erosion if cultivated and not protected.

Unit IVe–1. Deep, strongly sloping, moderately well drained soils with slow to moderately slow permeability and moderate to high available water capacity; on uplands.

Unit IVe–4. Deep, moderately sloping to strongly sloping, well drained to moderately well drained soils with slow to moderate to high available water capacity; on uplands.

Unit IVe–5. Deep, strongly sloping, moderately well drained soils with slow permeability and moderate available water capacity; on uplands.

Subclass IVs. Soils limited because of droughtiness.

Unit IVs–1. Deep, nearly level, excessively drained soils with very rapid permeability and low available water capacity; on bottom lands.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife habitat. (None in survey area.)

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.

Subclass VIe. Soils severely limited, chiefly by risk of erosion, unless protective cover is maintained.

Unit VIe–1. Deep, steep, well drained soils with moderate permeability and high available water capacity; on uplands.

Unit VIe–4. Deep, moderately steep to steep, well drained soils with moderate to moderately slow permeability and moderate to high available water capacity; on uplands.

Unit VIe–7. Deep to moderately deep, strongly sloping to steep, moderately well drained to well drained soils with moderate to slow permeability and moderate available water capacity; on uplands.

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

Subclass VIIe. Soils very severely limited by the risk of further erosion or damage caused by past erosion and by steepness of slopes.

Unit VIIe–7. Deep, moderately steep to steep, well drained soils with moderately slow permeability and moderate available water capacity; on uplands.

Unit VIIe–8. Shallow, strongly sloping, well drained soils with moderate permeability, very low available water capacity, and underlying soft shale bedrock; on uplands.

Class VIII. Soils and landforms in class VIII have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife habitat, and sources of sand and gravel.

Subclass VIIIe. Soils very severely limited because of devastating past erosion.

Unit VIIIe–1. Soils so badly dissected by deep gullies that it is impractical to use them for crops, pasture, or woodland. Slopes range from moderately sloping to those on clifflike escarpments. Soil material is mostly silt, silt loam, or silty clay loam, and in many areas soils are still actively eroding.

Subclass VIIIs. Soils very severely limited by droughtiness and gravel or sand content.

Unit VIIIs–1. Deep, nearly level, excessively drained sandy and gravelly riverwash with very rapid permeability and very low available water capacity; in or adjacent to stream channels on bottom lands.

Predicted Yields

Table 2 lists, for each soil in Howard County, the predicted average yields per acre of the principal crops. All available sources of yield information were used to make these estimates. They are based on the observations of the soil scientists that made the survey along with information obtained from local farmers, professional agrnomists, public and private agencies, demonstration plots, and research data.

Management practices, weather conditions, plant diseases, and insect manifestations vary from year to year and from place to place. Differences in any of these factors, especially the droughts during the summer months, cause great fluctuations in crop yields. Crop damage can also be locally heavy as a result of wind, hail, torrential downpours of rain, or flooding.

The table on yield predictions is based on an improved combination of management practices used by some of the farmers in the county. A systematic cropping plan consistent with the capability of the soils is followed. Sloping soils on uplands are terraced, and most slopes of more than 2 percent are farmed on the contour. Adequate drainage systems are installed as needed. Suitable high yielding varieties of plants are

TABLE 2.—*Predicted average yields per acre of the principal crops*

[Absence of yield indicates that the crop is not ordinarily grown in the soil]

Soil	Corn	Winter wheat	Soybeans	Grass-legume hay	Tall fescue
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]
Bremer silt loam	106		40	4.5	9.5
Carlow silty clay	72	30	26	3.3	6.6
Chariton silt loam	70	29	25	3.2	6.6
Edina silt loam	86	35	33	3.4	7.5
Fatima silt loam	102	42	38	4.5	9.0
Freeburg silt loam, 0 to 3 percent slopes	92	38	35	4.0	8.2
Gara and Armstrong loams, 5 to 9 percent slopes	78	33	30	3.3	7.0
Gara and Armstrong loams, 9 to 14 percent slopes	70	29	27	3.2	6.5
Gara and Armstrong clay loams, 5 to 9 percent slopes, severely eroded				3.1	6.2
Greenton silt loam, 2 to 5 percent slopes	84	35	31	3.7	7.4
Greenton silt loam, 5 to 9 percent slopes	77	31	28	3.4	6.8
Greenton silt loam, 9 to 14 percent slopes	67	28	25	3.1	6.2
Grundy silt loam, 2 to 5 percent slopes	90	38	34	4.0	8.0
Grundy silt loam, 5 to 9 percent slopes	80	34	30	3.6	7.2
Gullied land					
Hatton silt loam, 2 to 5 percent slopes	82	33	30	3.7	7.4
Hatton silt loam, 5 to 9 percent slopes	74	32	26	3.4	6.8
Haynie silt loam	96	40	36	3.6	
Hodge loamy fine sand	38	20	14	1.7	
Knox silt loam, 5 to 9 percent slopes	89	36	33	4.0	8.0
Knox silt loam, 9 to 14 percent slopes, severely eroded	70	30	25	3.2	6.6
Knox silt loam, 14 to 30 percent slopes, severely eroded				2.8	5.6
Ladoga silt loam, 2 to 5 percent slopes	113	47	43	4.7	9.5
Ladoga silt loam, 5 to 9 percent slopes	108	45	41	4.5	9.0
Leta silty clay	88	35	32	3.8	
Lindley loam, 14 to 30 percent slopes					4.5
Lindley clay loam, 14 to 30 percent slopes, severely eroded					4.0
Lindley and Keswick loams, 5 to 9 percent slopes	72	31	27	3.1	6.2
Lindley and Keswick loams, 9 to 14 percent slopes	62	28	24	2.7	5.4
Lindley and Keswick clay loams, 9 to 14 percent slopes, severely eroded				2.2	4.3
Mandeville silt loam, 5 to 9 percent slopes	60	30	21	2.7	5.2
Mandeville silt loam, 9 to 14 percent slopes	50	25	20	2.3	4.6
Mandeville silt loam, 14 to 30 percent slopes					3.4
Mandeville silty clay loam, 9 to 14 percent slopes, severely eroded				1.7	3.4
Marion silt loam	65	27	25	3.0	6.0
Marshall silt loam, 2 to 5 percent slopes	107	45	41	4.0	9.6
Marshall silt loam, 5 to 9 percent slopes	102	42	39	3.9	9.0
McGirk silt loam, 5 to 12 percent slopes	70	30	25	3.3	6.5
Menfro silt loam, 2 to 5 percent slopes	92	38	35	4.0	8.2
Menfro silt loam, 5 to 9 percent slopes	84	35	31	3.7	7.4
Menfro silt loam, 9 to 14 percent slopes	74	32	28	3.4	6.8
Menfro silt loam, 9 to 14 percent slopes, severely eroded	65	26	24	3.0	6.0
Menfro silt loam, 14 to 30 percent slopes				3.0	6.0
Mexico silt loam, 2 to 5 percent slopes	80	33	30	3.5	7.0
Moniteau silt loam	70	28	25	3.0	6.0
Napier silt loam, 2 to 5 percent slopes	105		40	4.0	8.0
Nodaway silt loam	110		42	4.6	9.0
Norris-Rock land complex, 10 to 30 percent slopes					2.0
Pershing silt loam, 2 to 5 percent slopes	101	36	38	4.2	8.6
Pershing silt loam, 5 to 9 percent slopes	96	33	36	4.0	8.0
Riverwash					
Sarpy sand		15		0.9	
Sharpsburg silt loam, 2 to 5 percent slopes	113	47	43	4.7	9.6
Sharpsburg silt loam, 5 to 9 percent slopes	108	45	41	4.5	9.0
Weller silt loam, 2 to 5 percent slopes	95	40	36	4.0	8.0
Weller silt loam, 5 to 9 percent slopes	90	37	34	3.8	7.5
Winfield silt loam, 2 to 5 percent slopes	98	42	38	4.4	8.8
Winfield silt loam, 5 to 9 percent slopes	92	40	36	4.1	8.2
Winfield silt loam, 9 to 14 percent slopes	82	35	32	3.7	7.4
Winfield silt loam, 9 to 14 percent slopes, severely eroded	72	30	26	3.3	6.6

[1] A.U.M. stands for animal-unit-month. It is the amount of forage required for one animal unit, 1,000 lb. cow or equivalent, for one month.

grown. Lime and fertilizer are regularly applied according to needs indicated by soil tests. Considerable attention is given to new methods of weed control and crop residue management. All farm operations are timely.

The yield predictions in table 2 are approximate figures and are intended to serve only as guides. Many users will consider the comparative yields between soils to be of more value than the actual yields. These relationships are likely to remain constant over a period of years.

Woodland Management and Productivity[2]

In 1972 about 63,000 acres, or 21 percent of Howard County (*5*), was wooded. The wooded tracts are owned by private individuals and are relatively small. They are used mainly for timber production, recreation, and wildlife habitat.

The principal forest type is upland oak consisting of white oak, black oak, northern red oak, post oak, and shagbark hickory. This type is primarily in the Lindley-Hatton-Mandeville and Winfield-Lindley-Mandeville soil associations.

Bottom land hardwoods consisting of eastern cottonwood and American sycamore are common to the Leta-Haynie-Hodge soil association.

The potential productivity of the soils for growing trees is moderate to moderately high for the upland hardwoods and high to very high for the bottom land species.

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

The first part of the symbol, a numeral, indicates the potential productivity of the soils for important trees. The numeral 1 indicates very high productivity; 2, high; 3, moderately high; 4, moderate; and 5, low. The second part of the symbol, a letter, indicates the major kind of soil limitation. The letter *w* indicates excessive water in or on the soil; *d,* restricted root depth; *c,* clay in the upper part of the soil; *s,* sandy texture; and *r,* steep slopes. The letter *o* indicates no significant limitations or restrictions. If a soil has more than one limitation, priority in placing the soil into a limitation class is in the order in which the letters are listed above—w, d, c, s, and r.

The third part of the symbol, a numeral, indicates the degree of hazard or limitation and general suitability of the soils for certain kinds of trees. The numerals and their meanings are as follows:

The numeral *1* indicates soils that have no limitations or only slight limitations and are best suited to coniferous species.

The numeral *2* indicates soils that have one or more moderate limitations and are best suited to coniferous species.

The numeral *3* indicates soils that have one or more severe limitations and are best suited to coniferous species.

The numeral *4* indicates soils that have no limitations or only slight limitations and are best suited to deciduous species.

The numeral *5* indicates soils that have one or more moderate limitations and are best suited to deciduous species.

The numeral *6* indicates soils that have one or more severe limitations and are best suited to deciduous species.

The numeral *7* indicates soils that have no limitations or only slight limitations and are best suited to either coniferous or deciduous species.

The numeral *8* indicates soils that have one or more moderate limitations and are best suited to either coniferous or deciduous species.

The numeral *9* indicates soils that have one or more severe limitations and are best suited to either coniferous or deciduous species.

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

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

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

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

Considered in the ratings of windthrow hazard are characteristics of the soil that affect the development of tree roots and the ability of soil to hold trees firmly. A rating of *slight* indicates that trees in wooded areas are not expected to be blown down by commonly occurring winds; *moderate,* that some trees are blown down during periods of excessive soil wetness and strong winds; and *severe,* that many trees are blown down during periods of excessive soil wetness and moderate or strong winds.

Ratings of plant competition indicate the degree to which undesirable plants are expected to invade or grow if openings are made in the tree canopy. The

[2] This section was prepared by GARY R. NORDSTROM, forester, Soil Conservation Service.

TABLE 3.—*Woodland management and productivity*

Soil name and map symbol	Ordination symbol	Management concerns					Potential productivity		Suitable species for planting
		Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Important trees	Site index	
Armstrong Mapped only with Gara soils.	4c5	Slight	Slight	Moderate	Slight	Slight.	White oak	55	Green ash.
							Northern red oak.	---	
Fatima: Fa	2o5	Slight	Slight	Slight	Slight	Moderate.	Pin oak	86	Eastern cottonwood, green ash, black walnut, pecan, American sycamore.
							Eastern cottonwood.	---	
Freeburg: Fr	3o4	Slight	Slight	Slight	Slight	Slight.	White oak	65	Eastern cottonwood, green ash, pecan, pin oak.
Gara: GaC, GaD, GcC3 For Armstrong part of GcC3, see Armstrong series.	4o4	Slight	Slight	Slight	Slight	Slight.	White oak	55	Green ash, black walnut.[1]
Hatton: HaB, HaC	4c5	Slight	Slight	Moderate	Slight	Slight.	White oak	54	Green ash.
							Black oak	59	
							Green ash	---	
Haynie: Hn	1o5	Slight	Slight	Slight	Slight	Moderate.	Eastern cottonwood.	115	Eastern cottonwood, black walnut, American sycamore.
							American sycamore.	---	
							Black walnut	---	
							Green ash	---	
Hodge: Ho	3s5	Slight	Slight	Moderate	Slight	Slight.	Eastern cottonwood.	90	Eastern cottonwood, American sycamore.
							American sycamore.	---	
Keswick Mapped only with Lindley soils.	4c5	Slight	Slight	Moderate	Moderate	Slight.	White oak	58	Green ash, pin oak, sweetgum, black walnut.
							Northern red oak.	---	
							Black oak	---	
							Pin oak	---	
Knox:									
KnC, KnD3	3o7	Slight	Slight	Slight	Slight	Slight.	White oak	65	Shortleaf pine, green ash, black walnut.
							Northern red oak.	---	
							Black walnut	---	
KnE3	3r8	Moderate	Moderate	Moderate	Slight	Slight.	White oak	65	Shortleaf pine, green ash, black walnut.
							Northern red oak.	---	
							Black walnut	---	

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

Soil name and map symbol	Ordination symbol	Management concerns: Erosion hazard	Management concerns: Equipment limitation	Management concerns: Seedling mortality	Management concerns: Windthrow hazard	Management concerns: Plant competition	Potential productivity: Important trees	Potential productivity: Site index	Suitable species for planting
Lindley:									
LnE, LrE3	4r5	Moderate	Moderate	Moderate	Slight	Slight.	White oak	60	Green ash, sweetgum, black walnut.[2]
							Black oak	63	
							Northern red oak.		
							Black walnut		
LsC, LsD, LwD3. For Keswick part of LsC, LsD, and LwD3, see Keswick series.	4o4	Slight	Slight	Slight	Slight	Slight.	White oak	60	Green ash, sweetgum, black walnut.[2]
							Black oak	63	
							Northern red oak.		
							Black walnut		
Mandeville:									
MaC, MaD, MbD3	4o4	Slight	Slight	Slight	Slight	Slight.	White oak	60	Green ash, sweetgum, black walnut.
							Black oak		
							Black walnut		
MaE	4r5	Moderate	Moderate	Moderate	Slight	Slight.	White oak	60	Green ash, sweetgum, black walnut.
							Black oak		
							Black walnut		
Marion: Mc	5w6	Slight	Severe	Moderate	Moderate	Severe.	Pin oak	45	Green ash, sweetgum, silver maple, pin oak.
							White oak	50	
							Black oak	50	
							Northern red oak.		
Marshall: MhB, MhC	3o7	Slight	Slight	Slight	Slight	Slight.	White oak	65	Black walnut, shortleaf pine, green ash.
							Northern red oak.		
							Black oak		
							Black walnut		
McGirk: MkC	4c5	Slight	Slight	Moderate	Slight	Slight.	White oak	55	Green ash, pin oak, pecan, eastern cottonwood, sweetgum.
Menfro:									
MnB, MnC, MnD, MnD3.	1o7	Slight	Slight	Slight	Slight	Slight.	White oak		Shortleaf pine, green ash, black walnut, sweetgum, silver maple.
							Northern red oak.	89	
							Black oak	87	
							Black cherry		
MnE	1r8	Moderate	Moderate	Moderate	Slight	Slight.	White oak		Shortleaf pine, green ash, black walnut, sweetgum, silver maple.
							Northern red oak.	89	
							Black oak	87	
							Black cherry		
Moniteau: Mu	5w6	Slight	Severe	Moderate	Moderate	Severe.	White oak	45	Pin oak, green ash, silver maple, sweetgum.
							Black oak		
							Northern red oak.		
							Pin oak		

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

Soil name and map symbol	Ordination symbol	Management concerns					Potential productivity		Suitable species for planting
		Erosion hazard	Equipment limitation	Seedling mortality	Windthrow hazard	Plant competition	Important trees	Site index	
Nodaway: Nd	2o7	Slight	Slight	Slight	Slight	Slight.	White oak Black walnut Eastern cottonwood.	80 ---------- ----------	Eastern cottonwood, pin oak, black walnut, pecan, silver maple, eastern white pine.
Norris: NoE	5d9	Severe	Moderate	Moderate	Moderate	Slight.	White oak Black oak	50 ----------	Shortleaf pine.
Pershing: PrB, PrC	4c5	Slight	Slight	Moderate	Slight	Slight.	White oak	55	Green ash.
Rock land. Mapped only with Norris soils. Too variable to be rated.									
Sarpy: Sa	5s6	Slight	Slight	Severe	Slight	Slight.	Eastern cottonwood.	60	Eastern cottonwood.
Sharpsburg: ShB, ShC	3o4	Slight	Slight	Slight	Slight	Slight.	White oak Black oak Black walnut	65 ---------- ----------	Black walnut, green ash.
Weller: WeB, WeC	4c5	Slight	Slight	Moderate	Slight	Slight.	White oak	55	Green ash.
Winfield: WnB, WnC, WnD, WnD3.	3o7	Slight	Slight	Slight	Slight	Slight.	White oak	65	Shortleaf pine, green ash, black walnut, sweetgum.

[1] Confine to selected sites.

[2] Confine to cool slopes, coves, benches, and slope bases.

invading plants compete with native plants or planted seedlings by impeding or preventing their growth. A rating of *slight* indicates little or no competition from other plants; *moderate* indicates that plant competition is expected to hinder the development of a fully stocked stand of desirable trees; *severe* means that plant competition is expected to prevent the establishment of a desirable stand unless the site is intensively prepared, weeded, or otherwise managed for the control of undesirable plants.

The potential productivity of merchantable trees on a soil is expressed as a site index. This index is the average height, in feet, that dominant and codominant trees of a given species attain in a specified number of years. The site index applies to fully stocked, even aged, unmanaged stands.

The site index for upland oak (*8*) species is the height reached in 50 years. The site index for eastern cottonwood (*4*) is the height reached in 30 years.

Use of soils for trees and shrubs for environmental improvement [3]

This section gives information about some of the trees, shrubs, and other vegetative cover used in landscaping sites for homes, schools, industry, and recreational areas. In planning, consideration should be given to wind protection, cover for critical areas, screening of unsightly areas, wildlife food and cover, and the general beauty of neighborhoods.

Trees and shrubs of different species vary widely in suitability to different soils and to site conditions. The soils in the county are placed in seven tree and shrub groups mainly on the basis of the amount of wetness from a seasonal high water table and from the available moisture capacity.

Each group of soils in a specific group has similar suitability for tree and shrub plantings. The soils in a tree and shrub suitability group can be identified by referring to the "Guide to Mapping Units" at the back of this survey.

Table 4 lists uses for specific plants on soils in the seven tree and shrub groups. This listing gives land users a good basis for planning the use of trees and shrubs for environmental improvement. In this table a listing is also made of some trees that grow naturally on soils in each of the seven soil groups. These are trees that may be retained when developing an area for more intensive public or private use. The plants listed in table 3 are only a partial list of plants suited to soils in the county. Many plants serve a dual purpose of landscaping and of providing food and cover for wildlife. If more detail is needed and pertinent landscaping plans are desired, landowners and others should contact local landscape specialists.

The properties of soils in each tree and shrub group that are important to the growth of plants are presented in the following paragraphs.

Group 1. All of the soils in this group are deep and somewhat excessively drained or moderately well drained. The water table is below a depth of 6 feet. Available water capacity is low or moderate. Slopes range from 0 to 30 percent.

Group 2. All of the soils in this group are moderately deep and well drained. The water table is below a depth of 6 feet. Available water capacity is moderate. These soils are droughty during some summer months. Slopes range from 9 to 35 percent.

Shrub group 3. The soil in this group is shallow and well drained. Soft shale bedrock lies within 20 inches of the surface. Available water capacity is very low. Slopes range from 10 to 30 percent.

Shrub group 4. All the soils in this group are deep and moderately well drained. The water table is generally below a depth of 6 feet. Available water capacity is very high. Slopes range from 5 to 30 percent.

Shrub group 5. All the soils in this group are deep and well drained or moderately well drained. The water table is generally below a depth of 5 feet. Available water capacity is high or very high. Slopes range from 0 to 5 percent.

Shrub group 6. All the soils in this group are deep and somewhat poorly drained. These soils have a perched or seasonal high water table. Available water capacity is moderate to very high. The soils are nearly level to moderately sloping.

Shrub group 7. All the soils in this group are deep and poorly drained or very poorly drained. These soils have a high water table and may be ponded at some time of the year. Available water capacity is moderate to high. The soils are nearly level to depressional and moderately sloping.

Use of the Soils for Wildlife Habitat [4]

Howard County is a mixture of flat and rolling prairie that is intersected by the breaks of the Missouri River tributaries. It is one of the counties that forms a transition zone between the prairie and the Ozark border. This region with its fairly rich and varied land types provides a variety and profusion of edge growth that makes excellent game cover (*7*). Much of the woodland is in drainage areas, draws, areas of steep soils, and scattered woodlots—all of which add diversity, interspersion, and an edge effect to the vegetative cover of the county.

The Grundy-Greenton-Sharpsburg, Knox-Marshall, Gara-Weller-Ladoga, Leta-Haynie-Hodge, and Nodaway-Fatima-Bremer soil associations provide the majority of the habitat for open land wildlife in the survey area. These associations support a medium to high population of rabbits, quail, and doves. Pheasants and prairie chickens are rarely seen in this county. Woodland habitat suitable for squirrels is limited in these associations, and the squirrel population fluctuates. Deer populations vary in size depending on the amount and distribution of adequate cover areas available.

The Lindley-Hatton-Mandeville, Menfro-Lindley-Norris, and Winfield-Lindley-Mandeville soil associations provide the bulk of the habitat for woodland wildlife. These wooded areas have a medium population of deer, medium to high numbers of gray squirrels, and a low population of turkeys. The number of open land species such as quail, rabbits, and doves depends on the amount of cropland, hayland, and pastureland in the particular association.

[3] GARY R. NORDSTROM, forester, Soil Conservation Service, assisted in the preparation of this section.

[4] EDWARD A. GASKINS, biologist, Soil Conservation Service, assisted in the preparation of this section.

TABLE 4.—*Suitability of soils for trees and shrubs for environmental improvement*

Description of tree and shrub group and soil series and map symbols	Trees to retain at home and park sites	Plantings for—			
		Beauty and shade	Attracting songbirds and wildlife	Critical areas	Windbreaks, screens, and sound barriers
Group 1: Deep, excessively drained to moderately well drained, nearly level to strongly sloping soils that have low to moderate available water capacity. Water table is at a depth of more than 6 feet. Armstrong: GaC, GaD, GcC3. Gara: GcC3. Greenton: GnB, GnC, GnD. Hatton: HaB, HaC. Hodge: Ho. Keswick: LsC, LsD, LwD3. Lindley: LnE, LrE3, LsC, LsD, LwD3. Sarpy: Sa.	White oak, northern red oak, black oak, black walnut, pin oak.	Alternateleaf dogwood, American hornbeam, Amur honeysuckle, Amur maple, Amur privet, Arnot bristly locust, autumn-olive, black oak, bur oak, Carolina laurelcherry, coralberry, crabapple, cutleaf staghorn sumac, eastern hophornbeam, eastern redbud, English yew, fragrant sumac, hackberry, hawthorn, Japanese yew, mallow ninebark, Nanking cherry, Norway maple, Oriental arborvitae, pawpaw, persimmon, red pine, scarlet oak, shadblow serviceberry, Siberian elm, silky dogwood, spreading cotoneaster, sugar maple, Tartarian honeysuckle, white ash, white oak, winged euonymus, yellow-poplar.	Alternateleaf dogwood, American hazel, American plum, Amur honeysuckle, Amur privet, Arnot bristly locust, autumn-olive, boxelder, bur oak, Carolina laurelcherry, coralberry, crabapple, eastern hophornbeam, eastern redcedar, English yew, fragrant sumac, Japanese yew, multiflora rose, Nanking cherry, Oriental arborvitae, pawpaw, persimmon, red pine, shadblow serviceberry, shrub lespedeza, silky dogwood, spreading cotoneaster, Tartarian honeysuckle, winged euonymus.	American hazel, Amur honeysuckle, Arnot bristly locust, autumn-olive, coralberry, cutleaf staghorn sumac, eastern redcedar, English yew, fragrant sumac, Japanese yew, mallow ninebark, multiflora rose, shrub lespedeza, Tartarian honeysuckle.	American plum, Amur honeysuckle, Amur maple, Amur privet, autumn-olive, boxelder, crabapple, eastern redcedar, hackberry, hawthorn, lilac, mallow ninebark, multiflora rose, Nanking cherry, Oriental arborvitae, osage-orange, red pine, Siberian elm, Tartarian honeysuckle, winged euonymus.
Group 2: Moderately deep, well drained, moderately sloping to steep soils that have moderate available water capacity. Water table is at a depth of more than 6 feet. Mandeville: MaC, MaD, MaE, MbD3.	White oak, northern red oak, green ash.	American cranberry bush, American hornbeam, American sycamore, Amur honeysuckle, Amur maple, Arnot bristly locust, autumn-olive, black oak, bur oak, Carolina laurelcherry, coralberry, cornelian cherry dogwood, crabapple, eastern hophornbeam, eastern redbud, English yew, flowering dogwood, fragrant sumac, hackberry, hawthorn, Japanese yew, lilac, mallow ninebark, mock-orange, Nanking cherry, Norway maple, Oriental arborvitae, pawpaw, pecan, persimmon, red pine, rose-of-sharon, scarlet oak, shadblow serviceberry, Siberian elm, silky dogwood, spreading cotoneaster, sugar maple, Tartarian honeysuckle, white ash, white oak, winged euonymus, yellow-poplar.	American cranberry bush, American hazel, American plum, Amur honeysuckle, Arnot bristly locust, autumn-olive, boxelder, bur oak, Carolina laurel cherry, coralberry, cornelian cherry dogwood, crabapple, eastern hophornbeam, eastern redcedar, English yew, flowering dogwood, fragrant sumac, Japanese yew, multiflora rose, Nanking cherry, Oriental arborvitae, pawpaw, pecan, persimmon, red pine, shadblow serviceberry, shrub lespedeza, silky dogwood, spreading cotoneaster, Tartarian honeysuckle, winged euonymus.	American hazel, Amur honeysuckle, Arnot bristly locust, autumn-olive, coralberry, eastern redcedar, English yew, fragrant sumac, Japanese yew, mallow ninebark, multiflora rose, shrub lespedeza, Tartarian honeysuckle.	American plum, Amur honeysuckle, Amur maple, autumn-olive, boxelder, crabapple, eastern redcedar, hackberry, hawthorn, lilac, mallow ninebark, mock-orange, multiflora rose, Nanking cherry, Oriental arborvitae, osage-orange, red pine, rose-of-sharon, Siberian elm, Tartarian honeysuckle, winged euonymus.

Group 3: Shallow, well drained, strongly sloping to steep soils that have very low available water capacity. Soft shale bedrock is at a depth of less than 20 inches. Norris: NoE.	White oak, black oak, shagbark hickory.	American hornbeam, Amur honeysuckle, Amur maple, Amur privet, Arnot bristly locust, autumn-olive, bur oak, coralberry, crabapple, eastern hophornbeam, hawthorn, lilac, mallow ninebark, mockorange, Oriental arborvitae, shadblow serviceberry, Siberian elm, silky dogwood, Tartarian honeysuckle, winged euonymous.	American plum, Amur honeysuckle, Amur privet, Arnot bristly locust, autumn-olive, bur oak, coralberry, crabapple, eastern hophornbeam, eastern redcedar, multiflora rose, Oriental arborvitae, silky dogwood, Tartarian honeysuckle, winged euonymus.	Amur honeysuckle, Arnot bristly locust, autumn-olive, coralberry, eastern redcedar, mallow ninebark, multiflora rose, shrub lespedeza, Tartarian honeysuckle.	American plum, Amur honeysuckle, Amur privet, autumn-olive, boxelder, crabapple, eastern redcedar, hawthorn, lilac, mallow ninebark, mockorange, multiflora rose, Oriental arborvitae, Tartarian honeysuckle, winged euonymus.
Group 4: Deep, well drained and moderately well drained, moderately sloping to steep soils that have high to very high available water capacity. Water table is at a depth of more than 6 feet most of the year. Gara: GaC, GaD. Knox: KnC, KnD3, KnE3. Ladoga: LaC. Marshall: MhC. Menfro: MnC, MnD, MnD3, MnE. Sharpsburg: ShC. Weller: WeC. Winfield: WnC, WnD, WnD3.	White oak, northern red oak, black oak, black walnut, black cherry.	Alternateleaf dogwood, American hornbeam, American sycamore, Amur honeysuckle, Amur maple, Amur privet, Arnot bristly locust, autumn-olive, black cherry, black locust, black oak, black walnut, bur oak, Chinese elm, coralberry, cornelian cherry dogwood, crabapple, eastern cottonwood, eastern hophornbeam, eastern redbud, eastern white pine, English yew, flowering dogwood, fragrant sumac, green ash, hackberry, hawthorn, Japanese yew, lilac, Lombardy poplar, mallow ninebark, mockorange, Nanking cherry, Norway maple, Ohio buckeye, Oriental arborvitae, pawpaw, pecan, persimmon, pin oak, pussy willow, redosier dogwood, red pine, rose-of-sharon, sassafras, scarlet oak, shadblow serviceberry, Siberian elm, silky dogwood, silver buffaloberry, silver maple, spreading cotoneaster, sugar maple, white ash, white oak, winged euonymus, yellow-poplar.	Alternateleaf dogwood, American hazel, American plum, Amur honeysuckle, Amur privet, Arnot bristly locust, autumn-olive, black cherry, black walnut, bur oak, Chinese elm, coralberry, cornelian cherry dogwood, crabapple, eastern hophornbeam, eastern redcedar, eastern white pine, English yew, flowering dogwood, fragrant sumac, Japanese yew, multiflora rose, Nanking cherry, Oriental arborvitae, pawpaw, pecan, persimmon, pin oak, pussy willow, redosier dogwood, red pine, sassafras, shadblow serviceberry, shrub lespedeza, silky dogwood, silver buffaloberry, spreading cotoneaster, Tartarian honeysuckle, winged euonymus.	American hazel, Amur honeysuckle, Arnot bristly locust, autumn-olive, black locust, coralberry, eastern redcedar, English yew, European alder, fragrant sumac, Japanese yew, mallow ninebark, multiflora rose, pussy willow, redosier dogwood, shrub lespedeza, silver buffaloberry, Tartarian honeysuckle.	American plum, Amur honeysuckle, Amur maple, Amur privet, autumn-olive, black willow, Chinese elm, crabapple, eastern cottonwood, eastern redcedar, eastern white pine, green ash, hackberry, hawthorn, lilac, Lombardy poplar, mallow ninebark, medium purple willow, mockorange, multiflora rose, Nanking cherry, Oriental arborvitae, osage-orange, pin oak, redosier dogwood, red pine, rose-of-sharon, Siberian elm, silver buffaloberry, Tartarian honeysuckle, winged euonymus.

TABLE 4.—*Suitability of soils for trees and shrubs for environmental improvement*—Continued

Description of tree and shrub group and soil series and map symbols	Trees to retain at home and park sites	Plantings for—			
		Beauty and shade	Attracting songbirds and wildlife	Critical areas	Windbreaks, screens, and sound barriers
Group 5: Deep, well drained and moderately well drained, nearly level to gently sloping soils that have high to very high available water capacity. Water table is at a depth of more than 5 feet most of the year. Fatima: Fa. Haynie: Hn. Ladoga: LaB. Marshall: MhB. Menfro: MnB. Napier: NaB. Nodaway: Nd. Sharpsburg: ShB. Weller: WeB. Winfield: WnB.	White oak, northern red oak, black oak, black walnut, black cherry.	Alternateleaf dogwood, American sycamore, Amur honeysuckle, Amur privet, Arnot bristly locust, black oak, bur oak, Chinese elm, coralberry, cornelian cherry dogwood, crabapple, eastern cottonwood, eastern hophornbeam, eastern redbud, eastern white pine, English yew, flowering dogwood, fragrant sumac, green ash, hackberry, hawthorn, Japanese yew, lilac, Lombardy poplar, mallow ninebark, Nanking cherry, Norway maple, Ohio buckeye, Oriental arborvitae, pawpaw, pecan, persimmon, pin oak, pussy willow, redosier dogwood, red pine, rose-of-sharon, sassafras, scarlet oak, shadblow, serviceberry, Siberian elm, silky dogwood, silver buffaloberry, silver maple, spreading cotoneaster, sugar maple, Tartarian honeysuckle, white ash, white oak, winged euonymus, yellow-poplar.	American hazel, Amur honeysuckle, Amur privet, Arnot bristly locust, bur oak, Chinese elm, coralberry, cornelian cherry dogwood, crabapple, eastern hophornbeam, eastern redcedar, eastern white pine, English yew, flowering dogwood, fragrant sumac, Japanese yew, multiflora rose, Nanking cherry, Oriental arborvitae, pawpaw, pecan, persimmon, pin oak, pussy willow, redosier dogwood, red pine, sassafras, shadblow serviceberry, shrub lespedeza, silky dogwood, silver buffaloberry, spreading cotoneaster, Tartarian honeysuckle, winged euonymus.	Alternateleaf dogwood, American hazel, Amur honeysuckle, Amur privet, Arnot bristly locust, coralberry, eastern redcedar, English yew, European alder, fragrant sumac, Japanese yew, mallow ninebark, multiflora rose, pussy willow, redosier dogwood, silver buffaloberry, Tartarian honeysuckle.	Amur honeysuckle, Amur privet, black willow, Chinese elm, crabapple, eastern cottonwood, eastern redcedar, eastern white pine, green ash, hackberry, hawthorn, lilac, Lombardy poplar, mallow ninebark, medium purple willow, multiflora rose, Nanking cherry, Oriental arborvitae, osageorange, pin oak, redosier dogwood, red pine, rose-of-sharon, Siberian elm, silver buffaloberry, Tartarian honeysuckle, winged euonymus.
Group 6: Deep, somewhat poorly drained, nearly level to moderately sloping soils that have a moderate to very high available water capacity. These soils have a seasonal high water table. Freeburg: Fr. Grundy: GrB, GrC. Leta: Le. McGirk: MkC. Mexico: MoB. Pershing: PrB, PrC.	White oak, black oak, pin oak.	Alternateleaf dogwood, American cranberry bush, Amur honeysuckle, Amur privet, Arnot bristly locust, black oak, bur oak, Chinese elm, coralberry, eastern hophornbeam, green ash, mallow ninebark, northern catalpa, Ohio buckeye, Oriental arborvitae, pecan, persimmon, pin oak, pussy willow, redosier dogwood, red pine, Russian-olive, silky dogwood, silver maple, sweetgum, Tartarian honeysuckle, white oak, willow oak.	American cranberry bush, Amur honeysuckle, Amur privet, Arnot bristly locust, bur oak, Chinese elm, coralberry, eastern hophornbeam, eastern redcedar, gray dogwood, mallow ninebark, multiflora rose, Oriental arborvitae, pecan, persimmon, pin oak, pussy willow, redosier dogwood, red pine, Russian-olive, shrub lespedeza, silky dogwood, Tartarian honeysuckle, willow oak.	Alternateleaf dogwood, Amur honeysuckle, Arnot bristly locust, coralberry, eastern redcedar, European alder, gray dogwood, mallow ninebark, multiflora rose, pussy willow, redosier dogwood, shrub lespedeza, Tartarian honeysuckle.	Amur honeysuckle, Amur privet, black willow, Chinese elm, eastern redcedar, gray dogwood, green ash, mallow ninebark, medium purple willow, multiflora rose, northern catalpa, Oriental arborvitae, pin oak, red pine, Russian-olive, Tartarian honeysuckle.

Group 7: Deep, poorly drained and very poorly drained, nearly level soils that have a moderate to high available water capacity. These soils have a seasonal high water table. Bremer: Br. Carlow: Ca. Chariton: Ch. Edina: Ed. Marion: Mc. Moniteau: Mu.	Pin oak, white oak, black oak, northern red oak.	Alternateleaf dogwood, American cranberry bush, Amur honeysuckle, Amur privet, Arnot bristly locust, black oak, bur oak, Chinese elm, coralberry, eastern hop-hornbeam, green ash, mallow ninebark, northern catalpa, Ohio buckeye, Oriental arborvitae, pin oak, pussy willow, redosier dogwood, sweetgum, Tartarian honeysuckle, white oak, willow oak.	American cranberry bush, Amur honeysuckle, Amur privet, Arnot bristly locust, bur oak, Chinese elm, coralberry, eastern hophornbeam, eastern redcedar, gray dogwood, multiflora rose, Oriental arborvitae, pussy willow, red pine, Russian-olive, shrub lespedeza, silky dogwood, Tartarian honeysuckle, willow oak.	Alternateleaf dog-wood, Amur honey-scukle, Arnot bristly locust, coralberry, eastern redcedar, European alder, gray dog-wood, mallow nine-bark, multiflora rose, pussy willow, redosier dogwood, shrub lespedeza, Tartarian honey-suckle.	Amur honeysuckle, Amur privet, black willow, Chinese elm, eastern red-cedar, gray dog-wood, green ash, mallow ninebark, medium purple willow, multiflora rose, northern catalpa, Oriental arborvitae, pin oak, red pine, Russian-olive, Tartarian honeysuckle.

The limited wetland wildlife areas are along the Missouri River in the Leta-Haynie-Hodge association and along the major tributaries of this river in the Nodaway-Fatima-Bremer association. Existing waterfowl population is low in Howard County.

Fishing is limited to certain areas of Howard County. Major streams include Bonne Femme Creek, Moniteau Creek, Sulphur Creek, Salt Creek, and Salt Fork. The Missouri River provides opportunities for fishing along the western and southern borders of the county. Public lake fishing is restricted to community water supply reservoirs and three private commercial fishing enterprises. Numerous farm ponds scattered throughout the county provide fishing for owners and invited guests. Major stream fishes include catfish, bass, carp, buffalo, and crappie. Ponds and lakes are generally stocked with a combination of largemouth bass, channel catfish, and bluegill.

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the development of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, inadequate, or inaccessible, wildlife will either be scarce or will not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by properly managing the existing plant cover, and by fostering the natural establishment of desirable plants.

In table 5 the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in—

1. Planning the use of parks, wildlife refuges, nature study areas, and other developments for wildlife.
2. Selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat.
3. Determining the intensity of management needed for each element of the habitat.
4. Determining areas that are suitable for acquisition to manage for wildlife.

The potential of the soil is rated *good, fair, poor,* or *very poor*. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, improved, or maintained in most places. Moderate intensity of management and fairly frequent attention are required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, barley, millet, buckwheat, cowpeas, soybeans, and sunflowers. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, and surface stoniness. The hazard of flooding is an important consideration. Soil temperature and soil moisture are also considerations.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bluegrass, lovegrass, switchgrass, bromegrass, timothy, orchardgrass, clover, alfalfa, trefoil, and crownvetch. Major soil properties that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations.

Wild herbaceous upland plants are native or naturally established herbaceous grasses and forbs, including weeds, on uplands that provide food and cover for wildlife. Examples are bluestem, indiangrass, goldenrod, beggarweed, pokeweed, foxtail, croton, switchgrass, partridgepea, and fescue. Major soil properties that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, and surface stoniness. The hazard of flooding is an important consideration. Soil temperature and soil moisture are also considerations.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage, that wildlife eat. Examples of native plants are oak, poplar, cherry, sweetgum, apple, hawthorn, dogwood, persimmon, sassafras, hickory, black walnut, and blackhaw. Major soil properties that affect growth of hardwood trees are depth of the root zone, available water capacity, and wetness.

Coniferous plants are cone bearing trees, shrubs, or ground cover that furnish habitat or supply food in the form of browse, seeds, or fruitlike cones. Examples are pine, spruce, hemlock, fir, yew, cedar, and juniper. Major soil properties that affect the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Shrubs are bushy woody plants that produce fruits, buds, twigs, bark, or foliage used as food, or that provide cover and shade for wildlife. Examples are sumac, hazelnut, wild plum, buttonbush, and certain dogwoods. Examples of fruit producing shrubs that are commercially available and suitable for planting on soils rated good are autumn-olive, Amur honeysuckle, Russian-olive, and hawthorne. Major soil properties that affect the growth of shrubs are depth of the root zone, available water capacity, and wetness.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Examples of wetland plants are smartweed, wild millet, rushes, sedges, cutgrass, wildrice, buttonbush, and cattail. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas are bodies of surface water that have an average depth of less than 5 feet and are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water control devices in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, and beaver ponds and other wildlife ponds. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. The availability of a dependable water supply is important if water areas are to be developed.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Habitat for open land wildlife consists of croplands, pastures, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, woodchuck, and mourning dove.

Habitat for woodland wildlife consists of hardwoods, conifers, or a mixture of both, with associated grasses, legumes, and wild herbaceous plants. Examples of wildlife attracted to this habitat are wild turkey, ruffed grouse, and woodcock; various thrushes, vireos, and woodpeckers; tree squirrels, gray fox, raccoon, deer, and black bear.

Habitat for wetland wildlife consists of water tolerant plants in open, marshy, or swampy shallow water areas. Examples of wildlife attracted to this habitat are ducks, geese, herons, shore birds, rails, and kingfishers and muskrat, mink, and beaver.

Use of the Soils for Recreational Development[5]

The Statewide Comprehensive Outdoor Recreation Plan (SCORP) (*9*) shows 4,847 acres of existing recreational developments in Howard County. The report also suggests additional bicycle paths, playfields, fishing areas, swimming areas, and foot trails by a target year of 1990. Existing horse trails and facilities for boating, sailing, hunting, camping, picnic, and winter sports are sufficient for the 1990 projected population of 10,859. The report further shows a total of 281 acres of State owned lands in the county that are open to the public for various forms of outdoor recreation. This figure includes one State park and one wildlife area. Also, part of the 3,324 acre Rudolf Bennet Wildlife Area is in the northeastern part of the county.

The NACD (Nationwide Outdoor Recreation Inventory (*6*)) shows three profit and three nonprofit private recreation enterprises in Howard County. These enterprises range from fishing lakes to a church camp. The committee which made the inventory felt that fishing waters and camping areas were the two priority recreation facilities needed in the county.

The soils of the survey area are rated in table 6 according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails. The ratings are based on such restrictive soil features as flooding, wetness, slope, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are the following: location and accessibility of the area, size and shape of the area and its scenic quality, ability of the soil to support vegetation, access to water, potential water impoundment sites available, and either access to public sewerlines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited in varying degrees for recreational use by the duration of the flooding and the season when it occurs. Onsite assessment of height, duration, and frequency of flooding is essential in planning recreational facilities.

In table 6 the limitations of soils are rated as *slight, moderate,* or *severe. Slight* means that the soil properties are generally favorable and that the limitations are minor and easily overcome. *Moderate* means that the limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 6 can be supplemented by additional information in other parts of this survey. Especially helpful are interpretations in table 8 for septic tank absorption fields, dwellings without basements, and local roads and streets.

Camp areas require such site preparation as shaping and leveling tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. Soils suitable for this use have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing camping sites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. Soils suitable for use as picnic areas are firm when wet, are not dusty when dry, and are not subject to flooding during the period of use. Also, they do not have slopes or stones or boulders that will increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. Suitable soils are level or nearly level and not wet or subject to flooding during the season of use. The surface is free of stones or boulders, is firm after rains, and is not dusty when dry. If shaping is required to obtain a uniform grade, the soil over rock should be sufficient to allow necessary grading.

The design and layout of paths and trails for walking, horseback riding, and bicycling should require little or no cutting and filling. Soils suitable for this use are those that are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once during the period of use. They should have moderate slopes and have few or no stones or boulders on the surface.

[5]Edward A. Gaskins, biologist, Soil Conservation Service, assisted in the preparation of this section.

TABLE 5.—*Suitability of soils for elements of*

Soil series and map symbol	Elements of wildlife habitat				
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants	Coniferous woody plants
Armstrong Mapped only with Gara soils.	Fair	Good	Good	Good	Good
Bremer: Br	Good	Fair	Good	Fair	Fair
Carlow: Ca	Poor	Poor	Fair	Fair	Fair
Chariton: Ch	Fair	Fair	Fair	Fair	Fair
Edina: Ed	Fair	Fair	Fair	Fair	Fair
Fatima: Fa	Good	Good	Good	Good	Good
Freeburg: Fr	Fair	Good	Good	Good	Good
Gara: GaC, GaD, GcC3. For Armstrong part, see Armstrong series.	Fair	Good	Good	Good	Good
Greenton:					
GnB, GnC	Fair	Good	Good	Good	Good
GnD	Fair	Fair	Good	Good	Good
Grundy: GrB, GrC	Fair	Good	Good	Good	Good
Gullied land: Gu. Too variable to be rated.					
Hatton: HaB, HaC	Fair	Good	Good	Good	Good
Haynie: Hn	Poor	Fair	Fair	Fair	Fair
Hodge: Ho	Poor	Fair	Fair	Fair	Fair
Keswick Mapped only with Lindley soils.	Fair	Good	Fair	Good	Good
Knox:					
KnC, KnD3	Fair	Good	Good	Good	Good
KnE3	Poor	Fair	Good	Good	Good
Ladoga:					
LaB	Good	Good	Good	Good	Good
LaC	Fair	Good	Good	Good	Good
Leta: Le	Fair	Fair	Fair	Good	Good
Lindley:					
LnE, LrE3	Poor	Fair	Good	Good	Good
LsC, LsD, LwD3 For Keswick part of LsC, LsD, and LwD3, see Keswick series.	Fair	Good	Good	Good	Good
Mandeville:					
MaC, MaD, MbD3	Fair	Good	Good	Good	Good
MaE	Poor	Fair	Good	Good	Good
Marion: Mc	Fair	Fair	Fair	Fair	Fair
Marshall:					
MhB	Good	Good	Good	Good	Good
MhC	Fair	Good	Good	Good	Good
McGirk: MkC	Fair	Good	Good	Good	Good

wildlife habitat and for classes of wildlife

Elements of wildlife habitat—Continued			Classes of wildlife		
Shrubs	Wetland food and cover plants	Shallow water developments	Open land	Woodland	Wetland
Good	Very poor	Very poor	Fair	Good	Very poor.
Fair	Good	Fair	Fair	Fair	Fair.
Fair	Poor	Good	Poor	Fair	Fair.
Fair	Good	Fair	Fair	Fair	Fair.
Fair	Good	Good	Fair	Fair	Good.
Good	Poor	Poor	Good	Good	Poor.
Good	Fair	Fair	Good	Good	Fair.
Good	Poor	Poor	Good	Good	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Poor	Poor	Fair	Fair	Poor.
Fair	Very poor	Very poor	Fair	Fair	Very poor.
Good	Poor	Poor	Fair	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Poor	Good	Good	Poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Fair	Fair	Good	Poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Fair	Good	Fair	Fair	Fair	Fair.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.

TABLE 5.—*Suitability of soils for elements of*

Soil series and map symbol	Elements of wildlife habitat				
	Grain and seed crops	Grasses and legumes	Wild herbaceous upland plants	Hardwood woody plants	Coniferous woody plants
Menfro:					
MnB	Good	Good	Good	Good	Good
MnC, MnD, MnD3	Fair	Good	Good	Good	Good
MnE	Poor	Fair	Good	Good	Good
Mexico: MoB	Fair	Good	Good	Good	Good
Moniteau: Mu	Fair	Fair	Fair	Fair	Fair
Napier: NaB	Poor	Fair	Fair	Good	Good
Nodaway: Nd	Good	Good	Good	Good	Good
Norris: NoE	Poor	Poor	Poor	Poor	Poor
Pershing:					
PrB	Good	Good	Good	Good	Good
PrC	Fair	Good	Good	Good	Good
Riverwash: Rw. Too variable to be rated.					
Rock land. Mapped only with Norris soils. Too variable to be rated.					
Sarpy: Sa	Poor	Poor	Fair	Poor	Poor
Sharpsburg:					
ShB	Good	Good	Good	Good	Good
ShC	Fair	Good	Good	Good	Good
Weller:					
WeB	Good	Good	Fair	Fair	Fair
WeC	Fair	Fair	Fair	Fair	Fair
Winfield:					
WnB	Good	Good	Good	Good	Good
WnC, WnD, WnD3	Fair	Good	Good	Good	Good

Engineering Uses of the Soils

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the soils on which they are built to predict performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 7 and 8, which show, respectively, several estimated soil properties significant to engineering and interpretations for various engineering uses.

This information, along with the soil map and other parts of this publication, can be used to make inter-

wildlife habitat and for classes of wildlife—Continued

Elements of wildlife habitat—Continued			Classes of wildlife		
Shrubs	Wetland food and cover plants	Shallow water developments	Open land	Woodland	Wetland
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Fair	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Good	Fair	Fair	Fair	Fair.
Good	Poor	Very poor	Fair	Good	Very poor.
Good	Fair	Poor	Good	Good	Poor.
Poor	Very poor	Very poor	Poor	Poor	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Poor	Very poor	Very poor	Poor	Poor	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Poor	Very poor	Good	Good	Very poor.
Fair	Poor	Poor	Good	Fair	Poor.
Fair	Poor	Poor	Fair	Fair	Poor.
Good	Poor	Very poor	Good	Good	Very poor.
Good	Very poor	Very poor	Good	Good	Very poor.

pretations in addition to those given in tables 7 and 8. It also can be used to make other useful maps.

This information, however, does not eliminate need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that are not known to all engineers. The Glossary defines many of these terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*2*) used by the SCS engineers, Department of Defense, and others, and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

The Unified system is used to classify soils according to engineering uses for building materials or for the support of structures other than highways. Soils are classified according to particle size distribution, plasticity index, liquid limit, and content of organic matter. Soils are grouped in 15 classes. Eight classes of coarse grained soils are subdivided on the basis of gravel and sand content. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. One class of highly organic soils, Pt, is also in this section. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL–ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. 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,

TABLE 6.—*Limitations of soils for recreational developments*

Soil series and map symbols	Picnic areas	Playgrounds	Camp areas	Paths and trails
Armstrong. Mapped only with Gara soils.	Moderate: wetness	Severe: wetness; slope; slow permeability.	Moderate: wetness; slow permeability.	Moderate: wetness.
Bremer: Br	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
Carlow: Ca	Severe: subject to flooding; wetness; too clayey.	Severe: subject to flooding; wetness; very slow permeability.	Severe: subject to flooding; wetness; very slow permeability.	Severe: wetness; too clayey.
Chariton: Ch	Severe: wetness	Severe: slow permeability; wetness.	Severe: slow permeability; wetness; subject to flooding.	Severe: wetness.
Edina: Ed	Severe: wetness	Severe: wetness; very slow permeability.	Severe: wetness; very slow permeability.	Severe: wetness.
Fatima: Fa	Moderate: subject to flooding.	Moderate: subject to flooding.	Severe: subject to flooding.	Moderate: subject to flooding.
Freeburg: Fr	Slight	Moderate: moderately slow permeability; subject to flooding.	Severe: subject to flooding; moderately slow permeability.	Slight.
Gara:				
GaC	Slight	Severe: slope	Moderate: moderately slow permeability.	Slight.
GaD	Moderate: slope	Severe: slope	Moderate: moderately slow permeability; slope.	Slight.
GcC3. For Armstrong part, see Armstrong series.	Moderate: too clayey.	Severe: slope	Moderate: moderately slow permeability; too clayey.	Moderate: too clayey.
Greenton:				
GnB, GnC	Slight	Severe: slope	Moderate: moderately slow permeability.	Slight.
GnD	Moderate: slope	Severe: slope	Moderate: moderately slow permeability; slope.	Slight.
Grundy:				
GrB	Moderate: wetness	Moderate: wetness; slow permeability.	Moderate: wetness; slow permeability.	Moderate: wetness.
GrC	Moderate: wetness	Severe: slope	Moderate: wetness; slow permeability.	Moderate: wetness.
Gullied land: Gu. Too variable to be rated.				
Hatton:				
HaB	Slight	Moderate: slope; very slow permeability.	Moderate: very slow permeability.	Slight.
HaC	Slight	Severe: slope	Moderate: very slow permeability.	Slight.
Haynie: Hn	Moderate: subject to flooding.	Moderate: subject to flooding.	Severe: subject to flooding.	Slight.
Hodge: Ho	Moderate: subject to flooding; too sandy; soil blowing.	Severe: subject to flooding; too sandy; soil blowing.	Severe: subject to flooding; too sandy; soil blowing.	Moderate: subject to flooding; too sandy; soil blowing.
Keswick. Mapped only with Lindley soils.	Moderate: wetness	Severe: slope; slow permeability.	Moderate: wetness; slow permeability.	Slight. Moderate: too clayey on severely eroded slopes of 9 to 14 percent.

TABLE 6.—*Limitations of soils for recreational developments*—Continued

Soil series and map symbols	Picnic areas	Playgrounds	Camp areas	Paths and trails
Knox:				
KnC	Slight	Severe: slope	Slight	Slight.
KnD3	Moderate: slope	Severe: slope	Moderate: slope	Slight.
KnE3	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Ladoga:				
LaB	Slight	Moderate: moderately slow permeability; slope.	Moderate: moderately slow permeability.	Slight.
LaC	Slight	Severe: slope	Moderate: moderately slow permeability.	Slight.
Leta: Le	Severe: too clayey	Severe: too clayey	Severe: subject to flooding; wetness.	Severe: too clayey.
Lindley:				
LnE, LrE3	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
LsC	Slight	Severe: slope	Moderate: moderately slow permeability.	Slight.
LsD	Moderate: slope	Severe: slope	Moderate: moderately slow permeability; slope.	Slight.
LwD3	Moderate: slope; too clayey.	Severe: slope	Moderate: moderately slow permeability; slope; too clayey.	Moderate: too clayey.
For Keswick part of LsC, LsD, and LwD3, see Keswick series.				
Mandeville:				
MaC	Slight	Severe: slope	Slight	Slight.
MaD	Moderate: slope	Severe: slope	Moderate: slope	Slight.
MaE	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
MbD3	Moderate: slope; too clayey.	Severe: slope	Moderate: slope; too clayey.	Moderate: too clayey.
Marion: Mc	Severe: wetness	Severe: wetness; very slow permeability.	Severe: wetness; very slow permeability.	Severe: wetness.
Marshall:				
MhB	Slight	Moderate: slope	Slight	Slight.
MhC	Slight	Severe: slope	Slight	Slight.
McGirk: MkC	Moderate: wetness; slow permeability.	Severe: slope	Moderate: wetness; slope; very slow permeability.	Moderate: wetness.
Menfro:				
MnB	Slight	Moderate: slope	Slight	Slight.
MnC, MnD, MnD3	Moderate: slope	Severe: slope	Moderate: slope	Moderate: slope.
MnE	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Mexico: MoB	Moderate: wetness	Severe: very slow permeability.	Severe: very slow permeability.	Moderate: wetness.
Moniteau: Mu	Severe: wetness	Severe: wetness	Severe: wetness; subject to flooding.	Severe: wetness.
Napier: NaB	Moderate: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Slight.
Nodaway: Nd	Severe: subject to flooding.	Severe: subject to flooding.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.
Norris: NoE	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
Pershing:				
PrB	Moderate: wetness	Moderate: slope; wetness; slow permeability.	Moderate: wetness; slow permeability.	Moderate: wetness.
PrC	Moderate: wetness	Severe: slope	Moderate: wetness; slow permeability.	Moderate: wetness.

TABLE 6.—*Limitations of soils for recreational developments*—Continued

Soil series and map symbols	Picnic areas	Playgrounds	Camp areas	Paths and trails
Riverwash: Rw. Too variable to be rated.				
Rock land. Mapped only with the Norris soils. Too variable to be rated.				
Sarpy: Sa	Severe: too sandy; soil blowing.	Severe: too sandy; soil blowing.	Severe: subject to flooding; too sandy; soil blowing.	Moderate: too sandy; soil blowing.
Sharpsburg:				
ShB	Slight	Moderate: moderately slow permeability.	Moderate: moderately slow permeability.	Slight.
ShC	Slight	Severe: slope	Moderate: moderately slow permeability.	Slight.
Weller:				
WeB	Moderate: wetness	Moderate: wetness; slow permeability.	Moderate: wetness; slow permeability.	Slight.
WeC	Moderate: wetness	Severe: slope	Moderate: wetness; slow permeability.	Slight.
Winfield:				
WnB	Slight	Moderate: slope	Slight	Slight.
WnC	Slight	Severe: slope	Slight	Slight.
WnD, WnD3	Moderate: slope	Severe: slope	Moderate: slope	Slight.

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 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. As additional refinement, the 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 estimated classification, without group index numbers, is given in table 7 for all soils mapped in the survey area.

USDA texture (*10*) 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." Where stones, cobbles, and gravel are in the soil, the modifiers "stony," "cobbly," and "gravelly" are used in textural descriptions.

Soil properties significant to engineering

Several estimated soil properties significant to engineering *(12)* are given in table 7. These estimates are made from layers of representative soil profiles having significantly different soil properties. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soils in other counties. In the following paragraphs are explanations of some of the columns in table 7.

Depth to bedrock is the distance from the surface of the soil to a rock layer within the depth of observation.

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 7 in the standard terms used by the Department of Agriculture (*10*). These terms are based on the percentages of sand, silt, and clay in the less than 2 millimeter fraction of the soil. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Liquid limit and plasticity index are water contents obtained by specified operations. As the water content of a clayey soil from which the particles coarser than 0.42 millimeter have been removed 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 a semisolid to a plastic state, and the liquid limit is the moisture content at which it changes 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 water content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 7.

Permeability, as used here, is an estimate of the rate at which saturated soil would transmit water in a vertical direction under a unit head of pressure. It is estimated on the basis of those soil characteristics observed in the field, particularly structure, porosity, and texture. Lateral seepage or such transient soil features as plowpans and surface crusts are not considered.

Available water capacity is an estimate of the capacity of soils to hold water for use by most plants. It is defined here as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most plants.

Reaction refers to the acidity or alkalinity of a soil, expressed in pH values for a stated soil-solution mixture. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential refers to the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils may damage building foundations, roads, and other structures. Soils having a high shrink-swell potential are the most hazardous.

Corrosivity, as used in table 7, pertains to potential soil induced chemical action that dissolves or weakens steel or concrete. Rate of corrosion of steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. A corrosivity rating of *low* means that there is a low probability of soil induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to reduce damage.

Engineering interpretations of soils

The estimated interpretations in table 8 are based on the engineering properties of soils shown in table 7, 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 Howard County. In table 8 ratings are used to summarize limitations or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, ponds and reservoirs, embankments, and terraces and diversions. For these particular uses table 8 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight, moderate,* and *severe. Slight* means that soil properties are generally favorable for the rated use, or in other words, that limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation special design, or intensive maintenance.

Soil suitability is rated by the terms *good, fair,* and *poor,* which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Explanations of some of the columns in table 8 are given in the following paragraphs.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from depths between 18 inches and 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption 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 the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are normally shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, content of organic matter, and slope. If the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted according to the Unified soil classification system and the amounts of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet; for examples, excavations for pipelines, sewer lines, phone and power transmissions lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings without basements, as rated in table 8, are not more than three stories high, and they are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting

TABLE 7.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. instructions for referring to other series that appear in the first column of

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal water table	Depth from surface	Dominant USDA texture	Classification Unified	Classification AASHTO	Coarse fraction greater than 3 inches
	Ft	*Ft*	*In*				
Armstrong. Mapped only with Gara soils.	>6	1–3	0–12	Loam and clay loam	CL or CL–ML	A–6	0
			12–36	Clay loam	CL or CH	A–7	0
			36–60	Clay loam	CL	A–6	0
Bremer: Br	>6	1–3	0–8	Silt loam	MH or CH	A–7	0
			8–60	Silty clay loam	CH	A–7	0
Carlow: Ca	>6	0–1	0–9	Silty clay	CL or CH	A–7	0
			9–60	Silty clay and clay	CL or CH	A–7	0
Chariton: Ch	>6	1–2	0–17	Silt loam	CL–ML or CL	A–4 or A–6	0
			17–20	Silty clay loam	CL	A–6 or A–7	0
			20–38	Silty clay	CH	A–7	0
			38–60	Silty clay loam	CL	A–6 or A–7	0
Edina: Ed	>6	½–2	0–16	Silt loam	ML or CL–ML	A–4 or A–6	0
			16–36	Silty clay	CH	A–7	0
			36–60	Silty clay loam	CL or CH	A–6 or A–7	0
Fatima: Fa	>6	3–5	0–10	Silt loam	CL–ML or CL	A–4 or A–6	0
			10–42	Silt loam	CL	A–6	0
			42–60	Silt loam	CL–ML or CL	A–4 or A–6	0
Freeburg: Fr	>6	1½–3	0–12	Silt loam	CL or CL–ML	A–4 or A–6	0
			12–19	Silty clay loam	CL	A–6 or A–7	0
			19–30	Clay loam	CL or CH	A–6 or A–7	0
			30–60	Silty clay loam	CL	A–6 or A–7	0
*Gara: GaC, GaD, GcC3. For Armstrong part, see Armstrong series.	>6	>6	0–11	Loam	CL	A–4 or A–6	0–5
			11–42	Clay loam	CL–CH	A–6 or A–7	0–5
			42–60	Clay loam	CL	A–6	0–5
Greenton: GnB, GnC, GnD	>6	2–3	0–12	Silt loam	CL–ML or CL	A–4 or A–6	0
			12–28	Silty clay loam and silty clay.	CH	A–7	0
			28–42	Clay	CH	A–7	0–5
			42–60	Weathered bedrock.			
Grundy: GrB, GrC	>6	1–3	0–11	Silt loam	CL–ML	A–7–5	0
			11–24	Silty clay loam	CH or CL	A–7–6	0
			24–42	Silty clay	CH	A–7–6	0
			42–60	Silty clay loam	CH or CL	A–7–6	0
Gullied land: Gu. Too variable to be estimated.							
Hatton: HaB, HaC	>6	2–3	0–8	Silt loam	CL–ML or CL	A–4 or A–6	0
			8–37	Silty clay loam and silty clay.	CL or CH	A–7	0
			37–46	Silty clay loam	CL	A–6	0
			46–60	Silty clay loam	CL	A–6 or A–7	0
Haynie: Hn	>6	>6	0–60	Silt loam and very fine sandy loam.	ML or CL	A–4 or A–6	0
Hodge: Ho	>6	>6	0–9	Loamy fine sand	SM	A–2 or A–4	0
			9–60	Loamy fine sand	SM	A–2 or A–4	0
Keswick. Mapped only with Lindley soils.	>6	1–3	0–10	Loam	CL or CL–ML	A–6 or A–4	0
			10–26	Clay	CH or MH	A–7	0
			26–60	Clay loam	CL or SC	A–6	0

significant to engineering

Because the soils in such mapping units can have different properties and limitations, it is necessary to follow carefully the this table. The symbol > means more than; the symbol < means less than]

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						In/hr	*In/in of soil*	*pH*			
95–100	80–95	75–90	55–80	20–35	5–20	0.6–2.0	0.20–0.22	5.1–6.5	Moderate	High	Moderate.
95–100	80–95	70–90	55–80	45–60	20–30	0.06–0.2	0.11–0.16	5.1–6.5	High	High	Moderate.
95–100	80–95	70–90	55–80	35–40	15–25	0.2–0.6	0.14–0.16	5.1–6.5	Moderate	High	Moderate.
100	100	100	95–100	45–60	25–40	0.2–0.6	0.21–0.23	5.6–6.5	Moderate	Moderate	Moderate.
100	100	100	95–100	50–65	20–35	0.06–0.2	0.15–0.17	6.1–6.5	High	Moderate	Moderate.
100	100	95–100	95–100	40–65	30–45	0.06–0.2	0.12–0.14	5.1–7.3	High	High	Moderate.
100	100	95–100	95–100	45–75	30–50	<0.06	0.09–0.12	4.5–6.0	High	High	Moderate.
100	100	90–100	85–100	25–35	5–15	0.6–2.0	0.22–0.24	5.1–6.5	Low	High	Moderate.
100	100	95–100	90–99	30–45	15–25	0.2–0.6	0.18–0.20	5.1–6.0	Moderate	High	Moderate.
100	100	95–100	90–100	55–70	35–45	0.06–0.2	0.11–0.13	5.1–7.3	High	High	Moderate.
100	100	95–100	90–99	30–45	15–25	0.2–0.6	0.18–0.20	6.1–7.3	Moderate	High	Low.
100	100	95–100	85–100	25–40	5–15	0.6–2.0	0.22–0.24	5.1–7.3	Moderate	High	Moderate
100	100	95–100	90–100	55–75	30–45	<0.06	0.11–0.13	5.6–7.3	Very high	High	Low.
100	100	95–100	90–100	35–60	15–35	0.06–0.2	0.18–0.20	6.6–7.3	High	High	Low.
100	100	95–100	85–100	25–40	5–18	0.6–2.0	0.22–0.24	6.1–7.3	Low	Moderate	Low.
100	100	95–100	90–100	30–40	12–18	0.6–2.0	0.20–0.22	6.1–7.3	Low	Moderate	Low.
100	100	95–100	85–100	25–40	5–18	0.6–2.0	0.20–0.22	6.1–7.3	Low	Moderate	Low.
100	100	90–100	90–100	15–35	5–15	0.6–2.0	0.22–0.24	6.1–7.3	Low	Moderate	Low.
100	100	85–100	85–100	30–45	15–25	0.6–2.0	0.18–0.20	5.1–6.0	Moderate	Moderate	Moderate.
100	100	90–100	70–90	35–55	20–30	0.2–0.6	0.15–0.19	4.5–5.5	Moderate	Moderate	High.
100	100	85–100	85–100	30–45	15–25	0.2–0.6	0.16–0.20	5.1–5.5	Moderate	Moderate	Moderate.
85–95	80–90	70–80	55–70	20–30	5–15	0.6–2.0	0.20–0.22	5.6–7.3	Moderate	Moderate	Moderate.
85–95	80–90	70–85	55–75	35–45	15–25	0.2–0.6	0.16–0.18	5.1–6.5	Moderate	Moderate	Moderate.
85–95	80–90	70–95	55–75	30–40	15–25	0.2–0.6	0.16–0.18	6.6–7.8	Moderate	Moderate	Moderate.
100	100	95–100	90–98	25–40	5–15	0.6–2.0	0.22–0.24	5.6–6.5	Low	High	Moderate.
100	100	97–100	95–99	52–70	35–45	0.06–0.2	0.11–0.15	6.1–7.3	High	High	Low.
65–100	65–100	60–95	55–90	50–70	25–40	0.06–0.2	0.08–0.12	6.6–7.8	High	High	Low.
100	100	95–100	90–98	30–45	5–15	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	High	Low.
100	100	97–100	95–99	45–55	30–40	0.2–0.6	0.18–0.20	5.1–7.3	High	High	Low.
100	100	97–100	95–99	50–70	30–45	0.06–0.2	0.11–0.13	5.1–6.5	High	High	Low.
100	100	97–100	95–99	45–55	30–40	0.06–0.2	0.18–0.20	5.6–7.3	High	High	Low.
100	100	92–100	80–98	25–40	5–15	0.6–2.0	0.22–0.24	5.1–6.0	Low	High	Moderate.
100	100	95–100	90–100	40–60	25–35	0.06–0.2	0.11–0.18	4.5–5.5	Moderate	High	Moderate.
100	85–95	80–90	75–85	25–40	10–20	<0.06–0.2	0.10–0.13	4.5–5.5	Low	High	Moderate.
95–100	80–95	70–90	60–85	30–45	15–25	0.06–0.2	0.14–0.18	5.1–6.0	Moderate	High	Moderate.
100	100	85–100	70–100	30–40	5–15	0.6–2.0	0.21–0.23	7.4–8.4	Low	Low	Low.
100	100	60–85	25–45	--------	[1] NP	>6.0	0.07–0.12	6.6–7.8	Very low	Low	Low.
100	100	60–85	25–45	--------	NP	>6.0	0.06–0.10	6.6–7.8	Very low	Low	Low.
95–100	80–100	75–90	60–80	20–30	5–15	0.6–2.0	0.14–0.18	4.5–6.0	Moderate	High	Moderate.
95–100	80–100	70–90	55–80	50–60	20–30	0.06–2.0	0.11–0.15	4.5–6.0	High	High	Moderate.
95–100	80–100	65–85	40–70	35–40	15–25	0.2–0.6	0.12–0.16	4.5–6.0	Moderate	High	Moderate.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to— Bedrock	Depth to— Seasonal water table	Depth from surface	Dominant USDA texture	Classification: Unified	Classification: AASHTO	Coarse fraction greater than 3 inches
	Ft	*Ft*	*In*				
Knox: KnC, KnD3, KnE3	>6	>6	0–11	Silt loam	CL–ML or CL	A–4	0
			11–38	Silt loam	CL	A–6	0
			38–60	Silt loam	CL–ML or CL	A–4 or A–6	0
Ladoga: LaB, LaC	>6	>6	0–11	Silt loam	ML or CL–ML	A–6 or A–4	0
			11–45	Silty clay loam and silty clay.	CL–CH	A–7	0
			45–60	Silty clay loam and silt loam.	CL	A–6	0
Leta: Le	>6	1–3	0–7	Silty clay	CL or CH	A–7	0
			7–60	Silty clay and silt loam.	CL or CH	A–6 or A–7	0
*Lindley: LnE, LrE3, LsC, LsD, LwD3. For the Keswick part of LsC, LsD, and LwD3, see Keswick series.	>6	>6	0–7	Loam	CL–ML or CL	A–4 or A–6	0
			7–60	Clay loam	CL	A–6 or A–7	0
Mandeville: MaC, MaD, MaE, MbD3.	1½–3	>6	0–8	Silt loam	ML or CL	A–4	0
			8–35	Silt loam and silty clay loam.	CL or ML	A–6 or A–4	0–5
			35–60	Weathered bedrock.			
Marion: Mc	>6	1–2	0–14	Silt loam	ML or CL	A–4 or A–6	0
			14–33	Silty clay	CH	A–7	0
			33–60	Silty clay loam	CL	A–6 or A–7	0
Marshall: MhB, MhC	>6	>6	0–13	Silt loam	CL	A–6 or A–7	0
			13–35	Silty clay loam	CL or CH	A–7	0
			35–60	Silt loam	CL–ML or CL	A–7	0
McGirk: MkC	>6	1–3	0–15	Silt loam	CL–ML or CL	A–4 or A–6	0
			15–60	Silty clay loam	CL or CH	A–6 or A–7	0
Menfro: MnB, MnC, MnD, MnD3, MnE.	>6	>6	0–12	Silt loam	CL	A–6	0
			12–60	Silty clay loam	CL	A–6 or A–7	0
Mexico: MoB	>6	1–2	0–15	Silt loam	CL–ML or CL	A–4 or A–6	0
			15–38	Silty clay and clay	CH	A–7	0
			38–60	Silty clay loam	CL	A–6 or A–7	0
Moniteau: Mu	>6	1–2	0–14	Silt loam	CL–ML or CL	A–4 or A–6	0
			14–42	Silty clay loam	CL	A–6 or A–7	0
			42–87	Silt loam and silty clay loam.	CL–ML or CL	A–4 or A–6	0
Napier: NaB	>6	>5	0–22	Silt loam	ML or CL	A–4 or A–6	0
			22–60	Silt loam	ML or CL	A–4 or A–6	0
Nodaway: Nd	>6	>6	0–41	Silt loam	CL	A–4 or A–6	0
			41–60	Silty clay	CH	A–7	0
Norris: NoE. Rock land part is too variable to be estimated.	½–1½	>6	0–13	Silt loam	ML or CL	A–4	2
			13–60	Weathered bedrock.			
Pershing: PrB, PrC	>6	2–4	0–17	Silt loam	CL	A–6	0
			17–49	Silty clay loam and silty clay.	CH	A–7	0
			49–60	Silty clay loam	CH or CL	A–7	0
Riverwash: Rw. Too variable to be estimated.							

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						In/hr	*In/in of soil*	*pH*			
100	100	95–100	92–100	20–30	5–10	0.6–2.0	0.22–0.24	5.6–7.3	Low	Low	Low.
100	100	95–100	95–100	30–40	10–20	0.6–2.0	0.18–0.20	5.6–7.3	Low	Low	Low.
100	100	95–100	92–100	25–35	5–15	0.6–2.0	0.20–0.22	6.1–7.8	Low	Low	Low.
100	100	100	95–100	25–40	5–15	0.6–2.0	0.22–0.24	6.1–6.5	Low	Moderate	Low.
100	100	100	95–100	41–55	23–35	0.2–0.6	0.18–0.20	5.1–6.0	Moderate	Moderate	Moderate.
100	100	100	95–100	30–40	15–20	0.2–0.6	0.18–0.20	5.1–6.5	Moderate	Moderate	Moderate.
100	100	95–100	95–100	45–65	30–45	0.06–0.2	0.12–0.14	7.5–7.8	High	High	Low.
100	100	95–100	90–100	35–65	20–40	0.06–0.2	0.11–0.19	6.6–8.4	High	High	Low.
95–100	90–100	85–95	50–65	15–30	5–15	0.6–2.0	0.16–0.18	4.5–6.0	Low	Moderate	Moderate.
95–100	90–100	85–95	55–75	30–45	15–25	0.2–0.6	0.14–0.18	4.5–7.8	Moderate	Moderate	Moderate.
100	100	90–100	75–95	20–30	NP–10	0.6–2.0	0.22–0.24	5.1–6.5	Low	Low	Moderate.
60–95	60–90	55–90	50–90	30–40	5–20	0.6–2.0	0.17–0.22	4.5–6.0	Low	Low	Moderate.
100	100	90–100	90–100	30–40	5–15	0.6–2.0	0.22–0.24	4.5–6.5	Low	High	Moderate.
100	100	95–100	90–100	50–65	30–40	<0.06	0.11–0.13	4.5–5.5	High	High	High.
100	100	95–100	85–95	35–45	20–25	<0.06	0.15–0.17	4.5–6.0	Moderate	High	Moderate.
100	100	95–100	95–100	35–50	15–25	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	Moderate	Moderate.
100	100	95–100	95–100	45–60	25–35	0.6–2.0	0.18–0.20	6.1–6.5	Moderate	Moderate	Low.
100	100	95–100	95–100	41–50	20–30	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low.
100	100	90–100	85–100	25–40	5–15	0.6–2.0	0.22–0.24	5.1–6.0	Low	Moderate	Moderate.
100	100	95–100	90–100	35–65	25–40	0.06–0.2	0.10–0.18	4.5–6.0	High	High	High.
100	100	95–100	92–100	25–35	11–20	0.6–2.0	0.22–0.24	5.1–7.3	Low	Low	Low.
100	100	95–100	95–100	35–45	20–25	0.6–2.0	0.18–0.20	5.1–7.3	Moderate	Low	Moderate.
100	100	95–100	90–98	25–40	5–20	0.6–2.0	0.22–0.24	5.1–7.3	Low	Moderate	Moderate.
100	100	97–100	95–100	55–75	32–48	<0.06	0.10–0.12	4.5–6.0	Very high	High	Moderate.
100	100	95–100	92–100	35–50	25–35	<0.06	0.12–0.14	5.1–7.3	High	High	Moderate.
100	100	90–100	85–100	25–35	5–15	0.2–0.6	0.21–0.23	5.6–6.5	Low	High	Moderate.
100	100	85–100	90–95	30–45	15–25	0.06–0.2	0.18–0.20	4.5–6.0	Moderate	High	High.
100	100	85–100	75–98	20–35	5–15	0.2–0.6	0.20–0.22	4.5–6.0	Low	High	Moderate.
100	100	95–100	95–100	25–40	8–20	0.6–2.0	0.22–0.24	6.1–7.3	Low	Low	Low.
100	100	95–100	95–100	25–40	8–20	0.6–2.0	0.20–0.22	6.1–7.3	Low	Low	Low.
100	95–100	95–100	90–100	25–35	5–15	0.6–2.0	0.20–0.23	6.1–7.3	Moderate	Moderate	Low.
100	100	95–100	90–100	50–65	30–40	<0.06	0.10–0.12	6.1–7.3	High	High	Low.
75–95	65–95	60–85	40–55	15–25	2–8	0.6–2.0	0.08–0.18	4.5–5.5	Low	Low	High.
100	100	100	95–100	30–40	11–20	0.6–2.0	0.22–0.24	4.5–6.5	Low	High	Moderate.
100	100	100	95–100	50–65	30–40	0.06–0.2	0.18–0.20	5.1–6.0	High	High	Moderate.
100	100	100	95–100	45–55	25–35	0.2–0.6	0.18–0.20	5.1–6.0	High	High	Moderate.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	Dominant USDA texture	Classification		Coarse fraction greater than 3 inches
	Bedrock	Seasonal water table			Unified	AASHTO	
	Ft	*Ft*	*In*				
Sarpy: Sa	>6	>6	0–11	Sand	SM	A-2	0
			11–60	Sand	SM	A-2	0
Sharpsburg: ShB, ShC	>6	>6	0–16	Silt loam	OL, CL, CH, or OH	A-6	0
			16–38	Silty clay loam	CH	A-7 or A-6	0
			38–60	Silt loam	CL	A-7 or A-6	0
Weller: WeB, WeC	>6	2–4	0–11	Silt loam	ML or CL	A-6 or A-4	0
			11–56	Silty clay loam and silty clay.	CH	A-7	0
			56–71	Silty clay loam	CH or CL	A-7	0
Winfield: WnB, WnC, WnD, WnD3.	>6	3–4	0–15	Silt loam	CL	A-6	0
			15–40	Silty clay loam	CL	A-6 or A-7	0
			40–60	Silt loam	CL–ML or CL	A-4 or A-6	0

[1] NP means nonplastic.

ground water, and trafficability. The best soils have moderately slow permeability, are able to withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 8 apply only to a depth of about 6 feet; therefore, limitation ratings of *slight* or *moderate* may not be valid if trenches are much deeper than that. Reliable predictions of some soils can be made to a depth of 10 to 15 feet, but regardless of that every site should be investigated before it is selected.

Local roads and streets, as rated in table 8, have an all weather surface that is expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load supporting capacity and stability of the subgrade and quantity and workability of available cut and fill material. The shrink-swell potential and the AASHTO and Unified classifications of the soil material indicate traffic supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as when preparing a seedbed; natural fertility of the material or its response to plants when fertilizer is applied; and absence of substances that are toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result to the area from which topsoil is taken.

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 resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among factors that are unfavorable.

Drainage of cropland and pasture is affected by permeability, texture, and structure of the soil; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope and 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; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; available water capacity; and need for drainage or depth to water table or bedrock.

Terraces and diversions are embankments or ridges *significant to engineering*—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential	Corrosivity to—	
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
						In/hr	*In/in of soil*	*pH*			
100	100	60–80	15–35	--------	NP	>20.0	0.05–0.09	6.6–8.4	Low	Low	Low.
100	100	60–80	15–35	--------	NP	>20.0	0.05–0.09	7.4–8.4	Low	Low	Low.
100	100	100	95–100	25–40	10–20	0.6–2.0	0.21–0.23	5.1–6.5	Moderate	Moderate	Moderate.
100	100	100	95–100	35–60	20–35	0.2–0.6	0.18–0.20	5.1–6.0	High	Moderate	Moderate.
100	100	100	95–100	35–50	20–30	0.2–0.6	0.18–0.20	6.1–6.5	High	Moderate	Moderate.
100	100	100	95–100	30–40	5–15	0.6–2.0	0.22–0.24	4.5–6.0	Low	High	Moderate.
100	100	100	95–100	50–65	30–40	0.06–0.2	0.12–0.18	4.5–6.0	High	High	Moderate.
100	100	100	95–100	45–55	20–30	0.2–0.6	0.18–0.20	5.1–6.0	High	High	Moderate.
100	100	95–100	92–100	25–40	11–20	0.6–2.0	0.22–0.24	5.6–8.3	Low	Moderate	Low.
100	100	95–100	95–100	35–45	20–25	0.6–2.0	0.18–0.20	4.5–6.0	Moderate	Moderate	Moderate.
100	100	95–100	92–100	25–35	5–15	0.6–2.0	0.20–0.22	5.1–6.0	Low	Moderate	Moderate.

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 slippage, and soil blowing. A suitable soil for these structures provides outlets for runoff and is not difficult to vegetate.

Formation and Classification of the Soils

The five factors of soil formation and their influence on the development of soils in Howard County are described in this section. Also, the system of soil classification is explained, and soil series of soils in Howard County are placed in higher categories of this system.

Factors of Soil Formation

Soil is produced by soil forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil. It may take a long or a short time for a profile to develop and thus form a soil, but generally, a long time is required for the development of distinct horizons.

The five factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Parent material is the unconsolidated mass from which a soil is formed. The formation or the deposition of this material is the first step in the development of a soil profile. The characteristics of the material determine the limits of chemical and mineralogical composition of the soil. In Howard County four principal kinds of parent material, alone or in combinations of two or more, have contributed to the formation of the soils. These four kinds are residual material weathered from bedrock; glacial, or ice deposited material; loess, or wind deposited material; and alluvium, or water deposited material. Of lesser importance is colluvium, which has been transported short distances downslope by the action of water and gravity.

Residual material, or residuum, has weathered from limestone, sandstone, and shale. Residuum from soft shale and thinly interbedded limestone is the parent material of Norris soils. Mandeville soils also formed in the weathered products of silty and clayey shale.

Glacial parent material composed of clay, silt, sand,

TABLE 8.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. instructions for referring to other series that

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill
Armstrong: GaC, GcC3	Severe: slow permeability.	Moderate: wetness; slope.	Severe: wetness.	Severe: shrink-swell potential; low strength.	Severe: wetness.
GaD. Mapped only with Gara soils.	Severe: slow permeability.	Severe: slope.	Severe: wetness.	Severe: shrink-swell potential; low strength.	Severe: wetness.
Bremer: Br	Severe: slow permeability.	Severe: wetness; excess humus.	Severe: wetness.	Severe: wetness; shrink-swell potential; low strength.	Severe: wetness; excess humus.
Carlow: Ca	Severe: very slow permeability; subject to flooding; wetness.	Slight where protected from flooding. Severe where flooding is common; wetness.	Severe: wetness; subject to flooding; too clayey.	Severe: wetness; subject to flooding; shrink-swell potential.	Severe: subject to flooding; wetness; too clayey.
Chariton: Ch	Severe: wetness; slow permeability.	Slight where protected from flooding. Severe where flooding is rare; wetness.	Severe: wetness.	Severe: wetness; shrink-swell potential; subject to flooding.	Severe: wetness.
Edina: Ed	Severe: slow permeability.	Slight	Severe: too clayey; wetness.	Severe: shrink-swell potential; wetness.	Severe: too clayey; wetness.
Fatima: Fa	Severe: subject to flooding.	Moderate where protected from flooding; seepage. Severe where flooding is common.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Freeburg: Fr	Severe: subject to flooding; wetness; moderately slow permeability.	Slight where protected from flooding. Severe where flooding is occasional; wetness.	Severe: subject to flooding; wetness.	Severe: subject to flooding.	Severe: subject to flooding.
*Gara: GaC, GcC3	Moderate: moderately slow permeability.	Moderate: slope.	Moderate: shrink-swell potential.	Moderate: shrink-swell potential.	Slight
GaD. For Armstrong part, see Armstrong series.	Moderate: moderately slow permeability.	Severe: slope.	Moderate: slope; shrink-swell potential.	Moderate: slope; shrink-swell potential.	Slight

engineering properties

Because the soils in such mapping units can have different properties and limitations, it is necessary to follow carefully the appear in the first column of this table]

Degree and kind of limitation for—Continued	Suitability as a source of—		Soil features affecting—				
Local roads and streets	Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Severe: shrink-swell potential; low strength.	Poor: low strength; shrink-swell potential.	Poor: area reclaim.	Slope	Shrink-swell potential; erodes easily.	Slow permeability.	Erodes easily; slope.	Erodes easily; slow permeability.
Severe: shrink-swell potential; low strength.	Poor: low strength; shrink-swell potential.	Poor: area reclaim.	Slope	Shrink-swell potential; erodes easily.	Slow permeability.	Erodes easily; slope.	Erodes easily; slow permeability.
Severe: wetness; shrink-swell potential; low strength.	Poor: shrink-swell potential; frost action potential; low strength.	Poor: wetness.	Favorable	Compressible; unstable fill; shrink-swell potential.	Slow permeability.	Slow intake rate; wetness.	Not needed.
Severe: wetness; subject to flooding; shrink-swell potential.	Poor: wetness; shrink-swell potential; low strength.	Poor: wetness; too clayey.	Favorable	Shrink-swell potential; compressible; low strength.	Subject to flooding; very slow permeability.	Slow intake rate; wetness; subject to flooding.	Very slow permeability; wetness.
Severe: wetness; frost action potential; shrink-swell potential.	Poor: wetness; shrink-swell potential.	Poor: wetness.	Favorable	Compressible; low strength.	Slow permeability; wetness.	Slow permeability; wetness.	Slow permeability; wetness.
Severe: shrink-swell potential; wetness.	Poor: shrink-swell potential; wetness.	Poor: wetness.	Favorable	Compressible; shrink-swell potential; low strength.	Slow permeability; wetness.	Slow intake rate; wetness; slow permeability.	Not needed.
Severe: subject to flooding; frost action potential.	Fair: low strength.	Good	Seepage	Compressible; low strength; piping.	Subject to flooding.	Subject to flooding.	Not needed.
Severe: subject to flooding.	Fair: shrink-swell potential; wetness.	Fair: thin layer.	Favorable	Compressible; low strength.	Subject to flooding; moderately slow permeability.	Subject to flooding; moderately slow permeability.	Moderately slow permeability; wetness.
Moderate: shrink-swell potential.	Fair: shrink-swell potential.	Fair: slope.	Slope	Favorable	Slope	Erodes easily.	Erodes easily; slope.
Moderate: slope; shrink-swell potential.	Fair: shrink-swell potential.	----------	----------	----------	----------	----------	----------

TABLE 8.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill
Greenton: GnB, GnC, GnD	Severe: moderately slow permeability.	Moderate: slope.	Severe: too clayey; wetness.	Severe: shrink-swell potential; low strength.	Severe: too clayey.
Grundy: GrB, GrC	Severe: slow permeability; wetness.	Moderate: slope.	Severe: wetness.	Moderate: wetness; shrink-swell potential.	Moderate: wetness.
Gullied land: Gu. Too variable to be estimated.					
Hatton: HaB, HaC	Severe: very slow permeability; wetness.	Moderate: slope.	Moderate: wetness.	Moderate: shrink-swell potential; wetness; low strength.	Moderate: too clayey.
Haynie: Hn	Severe where flooding is common. Slight where protected from flooding.	Severe where flooding is common. Moderate where protected from flooding; seepage.	Severe where flooding is common; subject to flooding. Slight where protected from flooding.	Severe where flooding is common; subject to flooding. Slight where protected from flooding.	Severe where flooding is common; subject to flooding. Slight where protected from flooding.
Hodge: Ho	Slight where protected from flooding. Severe where flooding is frequent.	Severe: subject to flooding; seepage.	Severe: subject to flooding; cutbanks cave.	Slight where protected from flooding. Severe where flooding is frequent.	Severe: subject to flooding; seepage.
Keswick:					
LsC	Severe: slow permeability.	Severe: wetness.	Severe: wetness.	Severe: shrink-swell potential; wetness; low strength.	Severe: wetness.
LsD, LwD3. Mapped only with Lindley soils.	Severe: slow permeability; slope.	Severe: slope.	Severe: wetness.	Severe: shrink-swell potential; wetness; low strength.	Severe: wetness.
Knox:					
KnC	Slight	Moderate: slope; seepage.	Slight	Slight	Slight
KnD3	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Moderate: slope.
KnE3	Severe: slope	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.

engineering properties—Continued

Degree and kind of limitation for—Continued	Suitability as a source of—		Soil features affecting—				
Local roads and streets	Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Severe: shrink-swell potential; low strength.	Severe: shrink-swell potential; low strength.	Fair: thin layer.	Slope	Low strength; shrink-swell potential; compressible.	Not needed	Slope; moderately slow permeability.	Slope; moderately slow permeability.
Severe: shrink-swell potential; low strength; wetness.	Poor: low strength; shrink-swell potential; wetness.	Fair: thin layer; too clayey.	Favorable	Shrink-swell potential; low strength.	Slow permeability; wetness.	Slow intake: wetness; slow permeability.	Slow permeability; wetness.
Severe: low strength.	Poor: low strength.	Fair: thin layer.	Slope	Low strength; shrink-swell potential; compressible.	Not needed	Slope; erodes easily; very slow permeability.	Slope; erodes easily.
Severe where flooding is common. Severe where protected from flooding; frost action potential.	Poor: frost action potential.	Good	Slope	Low strength; piping; erodes easily.	Not needed	Subject to flooding; excess lime.	Not needed.
Slight where protected from flooding. Severe where flooding is frequent.	Good	Poor: too sandy.	Seepage	Piping; unstable fill.	Not needed	Droughty; fast intake; soil blowing.	Not needed.
Severe: low strength; shrink-swell potential; frost action.	Poor: low strength.	Poor: area reclaim.	Slope	Shrink-swell potential; erodes easily; low strength.	Slow permeability.	Erodes easily; slope.	Slow permeability.
Severe: low strength; shrink-swell potential; frost action.	Poor: low strength.	Poor: area reclaim.	Slope	Shrink-swell potential; erodes easily; low strength.	Slow permeability.	Erodes easily; slope.	Slow permeability.
Slight	Poor: frost action.	Fair: thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Slope; erodes easily.
Moderate: slope.	Poor: frost action.	Fair: slope; thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Slope; erodes easily.
Severe: slope.	Poor: frost action.	Poor: slope.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Slope; erodes easily.

TABLE 8.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill
Ladoga: LaB, LaC	Severe: moderately slow permeability.	Moderate: slope.	Slight	Moderate: shrink-swell potential.	Moderate: too clayey.
Leta: Le	Severe: slow permeability; subject to flooding; wetness.	Moderate where protected from flooding; seepage. Severe where flooding is common; wetness.	Severe: subject to flooding; wetness.	Severe: wetness; subject to flooding; shrink-swell potential.	Moderate where protected from flooding; wetness; too clayey. Severe where flooding is common.
*Lindley: LnE, LrE3, LsD, LwD3	Severe: moderately slow permeability.	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.
LsC For Keswick part of LsC, LsD, and LwD3, see Keswick series.	Severe: moderately slow permeability.	Moderate: slope.	Moderate: slope; too clayey.	Moderate: shrink-swell potential; frost action.	Slight
Mandeville: MaC	Severe: depth to rock.	Severe: depth to rock; seepage.	Slight	Moderate: frost action.	Moderate: depth to rock.
MaD, MbD3	Severe: depth to rock.	Severe: depth to rock; seepage.	Moderate: slope.	Moderate: frost action.	Moderate: depth to rock.
MaE	Severe: depth to rock.	Severe: depth to rock; seepage.	Severe: slope.	Severe: slope.	Moderate: depth to rock; slope.
Marion: Mc	Severe: wetness; very slow permeability.	Slight	Severe: wetness.	Severe: wetness; shrink-swell potential.	Severe: wetness.
Marshall: MhB, MhC	Slight	Moderate: moderate permeability; slope.	Slight	Moderate: shrink-swell potential.	Slight
McGirk: MkC	Severe: slow permeability.	Severe: slope.	Severe: too clayey; wetness.	Severe: shrink-swell potential.	Severe: too clayey.
Menfro: MnB, MnC	Slight	Moderate: slope; seepage.	Slight	Moderate: shrink-swell potential.	Moderate: too clayey.
MnD, MnD3	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: slope.	Moderate: too clayey.

engineering properties—Continued

Degree and kind of limitation for—Continued	Suitability as a source of—		Soil features affecting—				
Local roads and streets	Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Severe: shrink-swell potential.	Poor: frost action.	Fair: too clayey.	Favorable	Compressible; low strength; shrink-swell potential.	Not needed	Erodes easily.	Favorable.
Severe: subject to flooding; shrink-swell potential; low strength.	Severe: shrink-swell potential; low strength.	Poor: too clayey.	Seepage	Compressible; low strength; seepage.	Subject to flooding; slow permeability; wetness.	Slow intake; wetness; subject to flooding.	Not needed.
Severe: slope.	Fair: frost action; shrink-swell potential.	Poor: slope.	Slope	Favorable	Not needed	Slope	Slope; moderately slow permeability; erodes easily.
Moderate: shrink-swell potential; frost action.	Fair: frost action; shrink-swell potential.	Fair: thin layer.	Slope	Favorable	Not needed	Slope	Slope; moderately slow permeability; erodes easily.
Moderate: frost action.	Fair: frost action.	Good	Depth to rock; slope; seepage.	Compressible; thin layer; seepage.	Not needed	Rooting depth; slope; seepage.	Depth to rock; rooting depth; slope.
Moderate: frost action.	Fair: frost action.	Good	Depth to rock; slope; seepage.	Compressible; thin layer; seepage.	Not needed	Rooting depth; slope; seepage.	Depth to rock; rooting depth; slope.
Severe: slope.	Fair: frost action.	Good	Depth to rock; slope; seepage.	Compressible; thin layer; seepage.	Not needed	Rooting depth; slope; seepage.	Depth to rock; rooting depth; slope.
Severe: wetness; shrink-swell potential.	Poor: wetness; shrink-swell potential.	Poor: wetness.	Favorable	Compressible; low strength; piping.	Very slow permeability; wetness.	Very slow permeability; wetness.	Very slow permeability; wetness.
Moderate: shrink-swell potential.	Fair: shrink-swell potential.	Fair: too clayey.	Moderate permeability.	Compressible; low strength; shrink-swell potential.	Not needed	Erodes easily.	Favorable.
Severe: shrink-swell potential; low strength.	Severe: shrink-swell potential; low strength.	Fair: too thin.	Favorable	Shrink-swell potential; compressible; low strength.	Not needed	Slow intake; wetness; slope.	Slow permeability; erodes easily; wetness.
Moderate: shrink-swell potential.	Fair: shrink-swell potential.	Fair: thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Erodes easily; slope.
Severe: slope.	Fair: shrink-swell potential.	Fair: thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Erodes easily; slope.

TABLE 8.—*Interpretations of*

Soil series and map symbols	Degree and kind of limitation for—				
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings without basements	Sanitary landfill
Menfro cont: MnE	Severe: slope	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: too clayey.
Mexico: MoB	Severe: very slow permeability; wetness.	Moderate: slope.	Severe: wetness.	Severe: shrink-swell potential.	Moderate: wetness; too clayey.
Moniteau: Mu	Severe: subject to flooding; wetness; slow permeability.	Slight where protected from flooding. Severe where flooding is occasional; wetness.	Severe: subject to flooding; wetness.	Severe: wetness; subject to flooding.	Severe: wetness; subject to flooding.
Napier: NaB	Slight	Moderate: seepage; slope; excess humus.	Moderate: wetness.	Moderate: wetness.	Slight
Nodaway: Nd	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Norris: NoE Rock land part is too variable to be estimated.	Severe: depth to rock; slope.	Severe: depth to rock; slope.	Severe: depth to rock; slope.	Severe: depth to rock; slope.	Moderate: depth to rock; slope.
Pershing: PrB, PrC	Severe: slow permeability; wetness.	Moderate: slope.	Moderate: wetness.	Severe: shrink-swell potential.	Moderate: too clayey; wetness.
Riverwash: Rw. Too variable to be estimated.					
Sarpy: Sa	Slight where protected from flooding. Severe where flooding is frequent; subject to flooding.	Severe: subject to flooding; seepage.	Severe: subject to flooding; cutbanks cave.	Slight where protected from flooding. Severe where flooding is frequent; subject to flooding.	Severe: subject to flooding; seepage.
Sharpsburg: ShB, ShC	Severe: moderately slow permeability.	Moderate: slope.	Slight	Severe: shrink-swell potential.	Moderate: too clayey.
Weller: WeB, WeC	Severe: slow permeability.	Slight	Moderate: wetness.	Severe: shrink-swell potential.	Moderate: too clayey.
Winfield: WnB, WnC	Severe: wetness.	Moderate: slope; seepage; wetness.	Moderate: wetness.	Moderate: shrink-swell potential.	Moderate: too clayey.
WnD, WnD3	Severe: wetness.	Severe: slope.	Moderate: wetness.	Moderate: shrink-swell potential.	Moderate: too clayey.

engineering properties—Continued

Degree and kind of limitation for—Continued	Suitability as a source of—		Soil features affecting—				
Local roads and streets	Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Severe: slope.	Fair: shrink-swell potential.	Fair: thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Erodes easily; slope.
Severe: shrink-swell potential; frost action.	Poor: shrink-swell potential; frost action.	Fair: thin layer.	Favorable	Shrink-swell potential; unstable fill.	Not needed	Slow intake; wetness; slope.	Very slow permeability; wetness.
Severe: wetness; subject to flooding; frost action.	Poor: wetness.	Poor: wetness.	Favorable	Compressible; low strength; piping.	Slow permeability; wetness.	Slow permeability; wetness.	Slow permeability; wetness.
Moderate: low strength; frost action.	Fair: low strength; frost action.	Good	Favorable	Low strength; piping.	Not needed	Slope	Favorable.
Severe: subject to flooding; frost action.	Poor: frost action.	Good	Seepage	Low strength.	Subject to flooding.	Subject to flooding.	Not needed.
Severe: depth to rock; slope.	Poor: thin layer; slope; area reclaim.	Poor: thin layer; area reclaim.	Depth to rock; slope.	Thin layer; erodes easily; hard to pack.	Not needed	Slope; rooting depth.	Depth to rock; slope; rooting depth.
Severe: shrink-swell potential.	Poor: shrink-swell potential.	Fair: area reclaim; thin layer.	Favorable	Compressible; low strength; shrink-swell potential.	Slow permeability; slope.	Wetness; slow intake.	Favorable.
Slight where protected from flooding. Severe where flooding is frequent; subject to flooding.	Good	Poor: too sandy.	Seepage	Piping; unstable fill; seepage.	Not needed	Droughty; fast intake; soil blowing.	Not needed.
Severe: shrink-swell potential; low strength.	Poor: shrink-swell potential; low strength.	Good	Favorable	Compressible; low strength; shrink-swell potential.	Not needed	Erodes easily.	Favorable.
Severe: shrink-swell potential.	Poor: shrink-swell potential.	Fair: area reclaim; thin layer.	Favorable	Compressible; low strength; shrink-swell potential.	Not needed	Erodes easily; slow intake.	Favorable.
Moderate: shrink-swell potential.	Fair: shrink-swell potential.	Fair: thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Slope; erodes easily.
Moderate: shrink-swell potential.	Fair: shrink-swell potential.	Fair: thin layer.	Seepage; slope.	Compressible; low strength; unstable fill.	Not needed	Slope; erodes easily.	Slope; erodes easily.

gravel, stones, and a few boulders was transported by ice action. Much of the material in the glacial till mass was moved long distances, but some of it is of fairly local origin. Soils of the Armstrong, Keswick, and Lindley series formed in glacial material.

Loess, a silty material transported by wind, is the most extensive of the parent materials in the survey area. The principal source is believed to have been the flood plain of the Missouri River in the period following the retreat of the last glacier. Deepest deposits of loess are on the hills bordering this flood plain. Here they formed the parent material of Menfro and Winfield soils. Further from the source, the windborne deposits were shallower and contained more clay. In the prairie region of the county, these materials were deposited in a setting ranging from moderately well drained to poorly drained. Here they formed the parent materials of the Sharpsburg, Grundy, and Edina soils. On the narrow ridgetops, loessial deposits were thin. Hatton soils formed in loess and the underlying glacial materials in this setting.

Alluvium makes up the parent material of all the bottom lands in Howard County. Reflecting the diverse origins and the varying speeds of flowing water, this material varies greatly in texture and in chemical and mineralogical composition. Bottom lands along small tributary streams are limited to local uplands for their source of alluvial parent material. Soils of the Missouri River flood plain have as their parent material source the vast drainage system of the "Big Muddy." Abundantly supplied with unweathered minerals, these soils, Haynie for example, are very fertile and have a high available water capacity. In contrast, Sarpy soils, which formed in sandy material washed largely from glacial deposits, are infertile and droughty.

Climate

Climate has been an important factor in the formation of the soils of Howard County. The effect of rainfall and temperature on soil formation continues to the present. As a result of climate in past ages, soil forming materials were deposited by ice and wind. Since that time climate has affected the soils that formed in these and other materials. The rate of geologic erosion varies with the climate, and the shape and character of the landforms that make up an area are influenced accordingly. Changes in the relative abundance and species composition of plant and animal life are directed by climatic changes. Present climatic conditions favor the growth of trees at the expense of prairie grasses. The prairie region in the county may be a relic of a more arid climatic cycle, but the reasons for its persistence until the time of settlement are not well understood.

Higher temperatures and rainfall encourage rapid chemical change and physical disintegration. Calcium carbonate and other soluble salts are removed by leaching, and fertility declines. Nearly all the upland soils in Howard County show these climatic effects.

Prominent layers of any kind in a soil, other than those formed in alluvium, indicate that chemical weathering has been intense. Examples are the claypans and bleached subsurface layers in Mexico and Marion soils and the fragipans in Hatton soils.

The influence of regional climate on soil formation is modified in many places by local conditions. For example, in some places shallow Norris soils with intermingled rock outcrops form on steep, south facing slopes under the influence of a microclimate which is warmer and less humid than on the opposite north facing slopes where the deeper Mandeville soils have formed.

Climate, then, has greatly influenced the nature and degree of weathering in the soils of the county; however, it probably did not fully control the growth of native vegetation.

Plant and animal life

In addition to the mineral matter provided by parent material, soils have another important component—organic matter. Plants, animals, insects, bacteria, and fungi are important in the formation of soils, and their more or less decomposed residue makes up the organic fraction of the material. Humus, or stable organic matter, is the part within this fraction that is resistant to further decomposition. It is black or brown in color and colloidal in nature. It has a capacity to hold and deliver water and nutrients to plants that exceeds that of clay, its inorganic counterpart. The presence of organic matter favorably affects granulation and tilth and greatly influences soil color, especially that of the surface layer. Exceptions to this are recent alluvial soils, which owe their color to that of the parent material in which they formed. The nitrogen supply and, to an extent, the natural fertility of a soil are directly related to its content of organic matter.

In the category of plant and animal life, the kind of native vegetation—prairie grasses versus forest trees—is the factor that has most profoundly influenced soil formation in Howard County. Prairie grasses and deciduous trees have marked differences in rooting habits, life span, and mineral composition, and there are significant differences in the micro-organisms and animals associated with each.

Organic matter additions to soils under forest are mostly in the form of leaves, twigs, and logs which decompose at the soil surface. These materials tend to be acid in reaction. This results in forest soils developing a very thin dark colored surface layer and leached subsurface layer.

In contrast, organic matter additions to soils under prairie grasses are largely due to the yearly death and decay of annual and biennial plants. Plant tops decompose at the surface, but a large share of this material is within the soil in the form of roots at various depths. The materials thus added tend to be richer in mineral composition than forest residue. As a result, soils that formed under prairie grasses have a much thicker dark colored surface layer and tend to be less acid than their forest counterpart that formed in similar parent material.

Slightly less than half of the survey area has soils that formed under prairie grasses. Grundy and Marshall are the most prevalent of these soils. These soils have what can be considered a counterpart that formed under forest trees with other factors being approximately equal. Thus, Grundy and Marion soils both formed in loess on gentle slopes. Marshall and Menfro soils also have similar settings. The factors of time and climate were equal or nearly equal in each case. In each of these paired examples, the marked differences in the soils are the result of differences in native vegetation—prairie grasses versus forest trees. Lindley and Mandeville are examples of the upland soils in the survey area that formed under forest and do not have counterparts that formed under prairie.

Micro-organisms, especially bacteria and fungi, play an important role in soil formation. They reduce raw and partially decomposed organic matter to humus, releasing plant nutrients in the process. Nodule bacteria fix atmospheric nitrogen essential to organic matter buildup.

Earthworms, insects, and burrowing animals have a favorable effect on tilth, fertility, and internal drainage.

The activities of man have had, in a remarkably short time, a profound effect on soil formation in Howard County. Originally the American Indian lived as a part of the natural ecosystem without significantly altering it. Alteration began with the first settlers and has continued at an accelerating pace. The prairie grasses have yielded to the plow. Nearly all the bottom lands and many upland areas have been cleared and are farmed. Huge machines till the soil and harvest the crops. Chemicals are used to fertilize desirable plants and to control unwanted plants and insects and other pests. Improved varieties of grain and forage crops are grown. These changes have helped bring about increased production of food, fiber, and timber products and a higher standard of living. The net effect of man's activities on soil formation has been adverse, however, in terms of sustained productivity. Most of the cropland in the county is subject to erosion. Accelerated erosion continues to reduce the potential of many soils, but man has the capacity to reverse this trend.

Relief

Relief, or topography, refers to the lay of the land. Relief may be characterized by gradient (degree or percent of slope) and by the length, shape, aspect, and uniformity of the slopes that make up a landscape. It is an important factor in determining the pattern and distribution of soils on a landscape because of its influence on drainage, runoff, and erosion.

Relief varies greatly in Howard County, ranging from that of the nearly level Missouri River bottom lands to the steep hillsides and vertical cliffs of the dissected upland areas. Other things being equal, more water enters the soil in areas of nearly level soils than in areas of more sloping soils. This water penetration intensifies leaching, translocation of clay, and other soil forming processes. Over long periods, subsoils high in clay content are formed beneath bleached subsurface layers. Edina and Marion soils show the results of these processes. At the other extreme are soils that formed on very steep slopes. Here runoff is excessive, and the rate of soil development is slowed. Removal of weathering products by geologic erosion almost keeps pace with the accumulation of such products. Norris and Mandeville soils were formed under these conditions.

Time

Time is necessary for the various processes of soil formation to act upon parent materials and form soil. The time involved may be very short or very long, and the soils of Howard County have a wide range of ages.

Perhaps the time factor can be best understood by considering the extremes. On the one hand we have "instant soils" left behind by flood waters receding from the Missouri River flood plain. These are the youngest soils of the area; indeed, some are even younger than the persons who farm them. Some of the recent Hodge, Haynie, Leta, and Sarpy soils on the river side of levees are examples. At the other extreme are soils that formed in loess in nearly level topography at the highest elevations in the survey area. These are the "old timers," the Chariton and Marion soils for example. They show their advanced age in a number of profile features. The carbonates originally present in their parent material have leached to great depths, leaving the soils quite acid throughout. Clays have been concentrated in distinct subsoil horizons, both by formation through weathering and through translocation by percolating water. Bleached subsurface horizons have formed by water tables perched above their impervious subsoils. All these processes have taken place over long periods.

Most soils in the area are intermediate between these extremes in age. Moniteau soils on stream terraces have developed an acid reaction and a clay-enriched subsoil. They formed in the same kind of alluvium as the "young" Nodaway soils on adjacent first bottoms, but in materials which have been in place much longer. Thus Moniteau soils can be considered "middle aged."

The shallow Norris soils that have steep slopes afford a somewhat different example. The shale from which the parent materials formed are far older than the oldest soil in the area. But removal of materials by geologic erosion almost keeps pace with accumulation through weathering. Thus these soils are considered "young."

From the foregoing, we see that the "age" of a soil, as expressed in profile characteristics, is not an absolute function of time, but is rather the result of the interaction of the other factors of soil formation over periods of time. Thus, in our discussion of time or age, we have reintroduced the factors of topography and climate. It should be remembered in any discussion of soil formation that we separate the various factors only for the purposes of study and understanding. No such isolation exists in nature.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship 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.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*11*, *13*).

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 9 the soil series of Howard County are placed in four categories of the current system (*11*). Classes of the current system are briefly defined in the following paragraphs.

ORDER.—Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols which occur in many different climates.

TABLE 9.—*Classification of soils*

Series	Family	Subgroup	Order
Armstrong	Fine, montmorillonitic, mesic	Aquollic Hapludalfs	Alfisols.
Bremer	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Carlow [1]	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
Chariton	Fine, montmorillonitic, mesic	Mollic Albaqualfs	Alfisols.
Edina	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Fatima	Fine-silty, mixed, mesic	Fluvaquentic Hapludolls	Mollisols.
Freeburg [1]	Fine-silty, mixed, mesic	Aquic Hapludalfs	Alfisols.
Gara [1]	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Greenton	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Grundy	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Hatton	Fine, montmorillonitic, mesic	Typic Hapludalfs	Alfisols.
Haynie	Coarse-silty, mixed (calcareous), mesic	Mollic Udifluvents	Entisols.
Hodge	Mixed, mesic	Typic Udipsamments	Entisols.
Keswick [1]	Fine, montmorillonitic, mesic	Aquic Hapludalfs	Alfisols.
Knox [1]	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Ladoga [1]	Fine, montmorillonitic, mesic	Mollic Hapludalfs	Alfisols.
Leta [1]	Clayey over loamy, montmorillonitic, mesic	Fluvaquentic Hapludolls	Mollisols.
Lindley	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Mandeville [1]	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Marion [1]	Fine, montmorillonitic, mesic	Albaquic Hapludalfs	Alfisols.
Marshall	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
McGirk [1]	Fine, montmorillonitic, mesic	Typic Ochraqualfs	Alfisols.
Menfro	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Mexico [1]	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Moniteau	Fine-silty, mixed, mesic	Typic Ochraqualfs	Alfisols.
Napier [1]	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Nodaway [1]	Fine-silty, mixed, nonacid, mesic	Mollic Udifluvents	Entisols.
Norris	Loamy, mixed, acid, mesic, shallow	Typic Udorthents	Entisols.
Pershing	Fine, montmorillonitic, mesic	Udollic Ochraqualfs	Alfisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Sharpsburg [1]	Fine, montmorillonitic, mesic	Typic Argiudolls	Mollisols.
Weller	Fine, montmorillonitic, mesic	Aquic Hapludalfs	Alfisols.
Winfield	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.

[1] These soils are taxadjuncts to the series for which they are named in that they are outside the range for the series in these characteristics:

Carlow soils have thicker mollic epipedons than allowed in the range.
Freeburg soils lack mottles and evidence of wetness directly below the Ap horizon.
Gara soils have finer textures in the upper part of the argillic horizon, a thinner B2 horizon, and more 5YR mottles than allowed in the range.
Keswick soils have grayer colors in the IIB23 and IIB3 horizons than allowed in the range.
Knox soils contain free carbonates above depths of 40 inches that are not allowed in the range.
Ladoga soils have grayer colors within depths of 30 inches than allowed in the range.
Leta soils have thicker mollic epipedons and deeper leaching of free carbonates than allowed in the range and are underlain by silty clay below depths of 40 inches.
Mandeville soils contain more clay in the B and C horizons than allowed in the range.
Marion soils contain more gray colors in the B horizon than are allowed in the range.
McGirk soils contain less clay in the B horizon than allowed in the range.
Mexico soils have a more abrupt increase in clay content between the A and B horizon than allowed in the range.
Napier soils have a thicker mollic epipedon than allowed in the range.
Nodaway soils lack values of 3 in the color of the Ap horizon and have silty clay below depths of 40 inches that is not allowed in the range.
Sharpsburg soils have darker colors in the upper B2 horizon than allowed in the range.

Each order is named with a word of three or four syllables ending in *sol* (Alf-i-sol).

SUBORDER.—Each order is subdivided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth; soil climate; the accumulation of clay, iron, or organic carbon in the upper part of the solum; cracking of soils caused by a decrease in soil moisture, and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Udalf* (*Ud,* meaning humid, and *alf,* from Alfisol).

GREAT GROUP.—Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constitutents have accumulated or have been removed, and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color. 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 horizons, *ud* for humid, and *alf,* from Alfisols).

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. Other subgroups may have soil properties unlike those 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* (a typical Hapludalf).

FAMILY.—Soil families are separated with a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae (table 9). An example is the fine-silty, mixed mesic family of Typic Hapludalfs.

Environmental Factors Affecting Soil Use

This section provides facts of interest about early settlement and population trends in Howard County and about relief and drainage; communications, transportation, and industry; educational, cultural, and recreational facilities; and climate.

Settlement and Population

Prior to the first white settlement, various tribes and bands of Indians occupied what is now Howard County. The Osage, Sac, Fox, Kickapoo, and Pottowatomie were the main tribes that the first pioneers encountered and later battled during the events surrounding the War of 1812.

Before the Louisiana Purchase in 1803, the area was under Spanish rule first, then, French rule. Explorers, especially under French charters, came into the Mississippi and Missouri Valleys in 1764. They began trapping for furs and trading with the Indians of the Howard County area before 1800. These French pioneers left their lasting mark in Howard County by the naming of the Bonne Femme and Moniteau streams on their maps and trading records.

Probably the first known landowner was Joseph Marie, a Frenchman who settled on a grant of land in 1800 in what is now Franklin township. After the sale of the vast Louisiana territory to the newly born United States, other settlers came into the area and laid claim to public lands at the mouth of the Lamine River in about July of 1804. Lewis and Clark, on their way up the Missouri River to the Great Northwest and the Pacific Ocean, stopped at a site near the mouth of the Bonne Femme River on June 7, 1804.

Most of the early explorers came only to trade and trap furs, but in 1807 Nathan and Daniel W. Boone, sons of the legendary hunter and pioneer, Daniel Boone, came to the Howard County area to make salt. They started a small settlement at Boone's Lick, a spot found by their famous father several years before. Their manufacturing site and the salt water springs are now preserved in a small state park west of Boonsboro.

In 1810 a colony of Kentuckians, about 150 families led by Benjamin Cooper, settled in the Missouri River bottom lands of what are now the townships of Boone's Lick and Franklin. These early settlers survived mainly by hunting and fishing, and reported that the deer, turkeys, elk, squirrels, rabbits, and partridges were so plentiful around their homesites that they were forced to kill them in order to save even part of their crops. The native forage was reported to be so good that their domestic livestock could live without being fed by the settlers, even when the ground was covered by snow. Their only use of corn at the time was to make bread.

During the period surrounding the War of 1812 the settlers lived in fear of their lives from British-inspired Indian raids. Many of the settlers were brutally massacred, and much of their livestock and other belongings were stolen or destroyed. In defense they built five small forts, and as a result much of the early community life and developments centered around these forts. The first cogwheel horse mill was built in 1815 at one of these forts, and the population grew to about 600. In 1816 the first county seat of Howard County was established across from Booneville at Old Franklin, the site of Coles Fort. The first steamboat to venture up the muddy Missouri River as far as Howard County stopped at Franklin in May of 1819. The first newspaper west of St. Louis was published there.

To escape the devasting flood experience at Franklin, a new site for the county seat was selected in 1823, and the new town of Fayette came into existence. The original Howard County area encompassed much of northwestern Missouri, and in 1825 it was reduced to its present size and boundaries.

By 1836 the village of Glasgow had become the principal river port for the shipping of the county's main exports—apples, tobacco, hemp, wheat, and pork. Although the railroads nearly ruined the economy of the area, it was later saved by the location of the Wabash terminal rail yards at Glasgow and the building of a railroad bridge across the Missouri River at that point.

Howard County continued to grow, but it has remained dominantly rural, and agriculture is still its main source of income. Population growth peaked in the 1900's and has gradually declined since then to the 1970 census figure of 10,561. Some small manufacturing has come into the area but the economic base is centered on the harvesting, storage, and shipping of corn, soybeans, wheat, and sorghum and a small amount of toabacco and tree fruits. The livestock industry is becoming more important, and raising beef cattle and hogs is the most important enterprise at the present.

Relief and Drainage

Howard County is completely within one major land resource area (*3*). It is in the Central Mississippi Valley Wooded Slopes area. This area consists mainly of an old glacial till plain that has been highly dissected by geologic erosion. The landscape is made up of narrow ridgetops and hilly to steeply sloping valley sides. Thick deposits of loess cover the areas closest to the Missouri River, gradually thinning to the east and north where the glacial till occupies the lower parts of side slopes. Exposures of the underlying Mississippian and Pennsylvanian age bedrock are in small outcroppings and escarpments along the more deeply entrenched drainageways and river bluffs. The smaller streams have narrow valleys and steep gradients. The Missouri River has a nearly level flood plain about three miles wide at the widest point. In the northeastern and eastern parts of the county, small areas of flat prairie soils occupy isolated remnants of the old broad ridgetops. These areas are very important locally for farming. Elevations range from about 400 feet in the Missouri River flood plain to about 1,000 feet on the highest ridges of the uplands.

All of the drainage from Howard County flows into the Missouri River. Some of the northeastern parts of the county drain westward into the Chariton River and some northward into Silver Creek, but eventually the water flows into the Missouri River.

The major tributaries are the Moniteau, Bonne Femme, and Sulfur creeks that flow southward directly into the Missouri River. Creeks of minor importance are the Batts, Greggs, Hurricane, Richland, Salt, Coopers, Bartlett, Salt Fork, and Hungry Mother. They flow either directly into the Missouri River or into one of the other tributaries.

Communication, Transportation, and Industry

Weekly newspapers are published in Fayette and Glasgow, and a rural farm magazine serving central Missouri is printed in Fayette. Telephone service and electric power are readily available to both rural and city residents. Radio and television reception is good in the area.

Transportation facilities are adequate, and they include a good network of county roads, four State Highways, and one Federal Highway. State Highways 3, 5, 87, and 240 serve the north-south traffic in the central and western parts of the county, and State Highway 124 serves the east-west traffic from east of Fayette. U.S. Highway 40 crosses the Missouri River at New Franklin and Booneville and serves the bottom lands to the east. Two major railroads serve Howard County; one line of the Illinois Central-Gulf Railroad passes through Glasgow to Armstrong and the northeastern part of the county; the other, the Missouri, Kansas, and Texas Railroad, has one line running north and south through the center of the county and serving New Franklin and Fayette and another line from New Franklin to Rocheport and eastward. Some shipping is still done by barge and river tugboat, and Glasgow is the main port in Howard County.

Grain, feed, and equipment markets are at Glasgow and Fayette. Booneville, across the Missouri River from New Franklin, is a major trading center for southern Howard County areas. Livestock auctions and sales are centered near Fayette, and major markets in Kansas City and St. Louis are easily reached by trucks. Small manufacturers of wearing apparel and steel products are also in Fayette and Glasgow. Some strip mining for coal is carried on in small operations in the northeast part of the county.

Educational, Cultural, and Recreational Facilities

High schools are in Glasgow, Fayette, and New Franklin, and the county is served by a consolidated system of elementary schools. Central Methodist College is in Fayette, and one parochial elementary school is conducted by the local Catholic churches.

The county has limited recreational facilities in one small state park and the state controlled Hungry Mother and Rudolph Bennett game and wildlife areas in the northeastern parts of the county. Old Lake Fayette and other small private impoundments of pond and lake size waters help to serve some of the local needs for water sports and fishing. Some fishing is done along the banks of the Missouri River and its inland tributaries.

Climate[6]

Fayette, Missouri, is just north of the Missouri River in the central part of the State. The terrain immediately around Fayette is gently rolling farmland that has elevation above sea level close to 800 feet.

Annual precipitation at Fayette varies from about 23 inches in a very dry year to about 48 inches in a very wet one. Winter precipitation totals are typically light, as compared to the total amounts that fall during the spring and early summer months. On the average, April through August is the period when more than

[6] Prepared by JAMES D. MCQUIGG, Professor of Atmospheric Science, College of Agriculture, University of Missouri, Columbia.

half of the total annual precipitation can be expected to occur.

Each of the 30 years of weather records from Fayette (used in the preparation of this section) included observations of snowfall. In three of the 30 years less than 10 inches of snow fell, and in five of the 30 years more than 27 inches fell. The most likely month for heavy snow is March.

During the crop season, there is a tendency for rainfall to be less during July, which is also the time that row crops need the largest amounts of water.

Fayette is subject to large changes of temperature from season to season. The fall and winter months have the largest day to day variations, while summer temperatures change more slowly from one day to the next. January and February are the coldest months (the all time record low of 26 F° was observed in February prior to 1931), but prolonged periods of cold temperatures are rare. In the period 1931-1960 there were 21 Januarys that had at least five days having a temperature of 50 F° or more. In that same 30-year period there were only five Januarys that had five or more days with a temperature of zero or below.

July is the hottest month on the average. (The all-time record of 116 F° was reported in July prior to 1931.) One would expect to have at least one day with a temperature as high as 100 F° in about half of the Julys in Fayette.

Relative humidity and wind data have not been recorded at Fayette, but these can be reasonably interpolated from the records of the Weather Bureau Airport Station at Columbia, Missouri. The mean hourly wind speed varies from close to 8 miles per hour in the summer to nearly 11 miles per hour in the fall, winter, and spring. The prevailing wind direction is either southerly or southeasterly.

Temperature and precipitation data are presented in table 10. The column "average heating degree-days" in table 10 provides a comparative number, or average, for calculating relative heating requirements for dwellings. Fuel consumption for heating is proportional to total degree-days; that is, a month that has twice as many degree-days as another month requires twice as much fuel for heating.

Probabilities of last freezing temperatures in spring and first in fall are presented in table 11. Probabilities in a 10 year period are based on previous records of freezing temperatures. Separate entries are listed for freezing temperatures of 16° or lower, 20° or lower, 24° or lower, 28° or lower, and 32° or lower.

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TABLE 10.—*Temperature and*

Month	Temperature					Average heating degree-days[1]	Precipitation
	Average daily maximum	Average daily minimum	Average	Record high	Record low		Rainfall: Average
	°F	°F	°F	°F	°F		Inches
January	39.9	20.1	30.0	77	−21	1,082	1.61
February	44.4	23.6	34.0	79	−18	875	1.73
March	53.6	31.2	42.4	85	−10	702	2.58
April	66.3	42.9	54.6	91	16	331	3.39
May	75.3	52.7	64.0	105	29	114	4.60
June	84.5	62.4	73.4	108	38	12	4.47
July	89.7	66.1	77.9	116	48	0	3.47
August	88.5	65.0	76.7	112	44	2	3.72
September	82.2	56.2	69.2	104	28	54	3.11
October	71.0	45.5	58.3	97	17	242	2.99
November	54.2	32.2	43.2	84	1	655	2.21
December	43.3	24.2	33.7	72	−14	968	1.78
Year	66.1	43.5	58.5	116	−21	5,037	35.66

[1] Based on a temperature of 65° F and computed from average monthly temperatures. These data show relative heating requirements for dwellings. Degree-days for a single day are obtained by subtracting the average temperature of the day from 65° F.

(9) State Interagency Council for Outdoor Recreation. 1970. Missouri statewide comprehensive outdoor recreation plan. (SCORP). Vol. 2, Dec. 1970.
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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Base saturation. The degree to which material having base exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Chert. A very dense, cryptocrystalline, flintlike form of silica that breaks with a splintery fracture. It resists decomposition and generally remains as inert angular fragments in the residual mass. Chert fragments are up to 3 inches in diameter.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coat, clay skin.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is com-

precipitation data

Precipitation—Continued				Precipitation of .01 inch or more	Average number of days with—			
Rainfall—Continued	Snow and sleet				Maximum temperature of—		Minimum temperature of—	
Maximum for 24 hours	Average	Maximum for month	Maximum for 24 hours		90° F and above	32° F and below	Between 0° F and 32° F	0° F and below
Inches	*Inches*	*Inches*	*Inches*					
1.80	4.3	13.7	10.0	4	0	9	28	2
1.40	4.3	13.7	12.0	4	0	5	23	1
2.32	4.7	27.3	10.6	5	0	2	18	([2])
3.07	.4	4.0	4.0	7	([2])	([2])	5	0
2.51	0	0	---	8	1	0	([2])	0
3.90	0	0	---	7	8	0	0	0
4.03	0	0	---	5	16	0	0	0
3.70	0	0	---	6	14	0	0	0
3.46	0	0	---	5	7	0	([2])	0
3.30	0	0	---	5	1	0	3	0
2.70	1.4	7.5	7.5	4	0	1	16	0
2.72	4.3	13.0	8.0	4	0	6	25	1
4.03	19.4	27.3	12.0	64	48	23	118	4

[2] Less than one half day.

TABLE 11.—*Probability of last freezing temperature in spring and first in fall*

Probability	Dates for given probability and temperatures				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	March 25	April 3	April 12	April 23	May 3
2 years in 10 later than	March 20	March 28	April 7	April 18	April 28
5 years in 10 later than	March 11	March 17	March 29	April 8	April 19
Fall:					
1 year in 10 earlier than	November 11	November 1	October 24	October 8	September 29
2 years in 10 earlier than	November 17	November 5	October 28	October 14	October 5
5 years in 10 earlier than	November 27	November 14	November 6	October 25	October 17

monly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Fragipan. A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Habitat. The natural abode of a plant or animal; refers to the kind of environment in which a plant or animal normally lives, as opposed to the range or geographical distribution.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Intensive cropping. Maximum use of the land through the frequent growing of harvested crops.

Landscape. All the characteristics that distinguish a certain kind of area on the earth's surface and give it a distinguishing pattern, in contrast to other kinds of areas. Any one kind of soil is said to have a characteristic natural landscape, and under different uses it has one or more characteristic cultural landscapes.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows:

abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of the three single variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

pH value. (See Reaction, soil). A numerical designation of acidity and alkalinity in soil.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		pH
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulates over disintegrating rock.

Runoff. The precipitation discharged in stream channels from a drainage area. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called groundwater runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Second bottom. The first terrace above the normal flood plain of a stream.

Second growth (forestry). Forest that originates naturally after removal of a previous stand by cutting, fire, or other cause. A loosely used term for young stands.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil depth. Refers to the depth of the soil profile, including the C horizon if present, over bedrock or other strongly contrasting nonconforming rock material. In this survey the following classes are used:

Shallow	10 to 20 inches
Moderately deep	20 to 40 inches
Deep	over 40 inches

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil (engineering). Presumably a fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs. In referring to a capability unit read the introduction to the section. It provides general information about its management.

Map symbol	Mapping unit	Page	Capability unit Symbol	Tree and shrub group Number
Br	Bremer silt loam	11	IIw-2	7
Ca	Carlow silty clay	12	IIIw-14	7
Ch	Chariton silt loam	13	IIw-2	7
Ed	Edina silt loam	14	IIw-2	7
Fa	Fatima silt loam	15	IIw-1	5
Fr	Freeburg silt loam, 0 to 3 percent slopes	16	IIw-1	6
GaC	Gara and Armstrong loams, 5 to 9 percent slopes	17	IIIe-1	1,4
GaD	Gara and Armstrong loams, 9 to 14 percent slopes	17	IVe-1	1,4
GcC3	Gara and Armstrong clay loams, 5 to 9 percent slopes, severely eroded	17	IVe-4	1
GnB	Greenton silt loam, 2 to 5 percent slopes	18	IIe-5	1
GnC	Greenton silt loam, 5 to 9 percent slopes	18	IIIe-5	1
GnD	Greenton silt loam, 9 to 14 percent slopes	19	IVe-5	1
GrB	Grundy silt loam, 2 to 5 percent slopes	20	IIe-5	6
GrC	Grundy silt loam, 5 to 9 percent slopes	21	IIIe-5	6
Gu	Gullied land	21	VIIIe-1	--
HaB	Hatton silt loam, 2 to 5 percent slopes	22	IIe-4	1
HaC	Hatton silt loam, 5 to 9 percent slopes	23	IIIe-4	1
Hn	Haynie silt loam	23	I-1	5
Ho	Hodge loamy fine sand	24	IIIs-1	1
KnC	Knox silt loam, 5 to 9 percent slopes	26	IIIe-1	4
KnD3	Knox silt loam, 9 to 14 percent slopes, severely eroded	26	IVe-4	4
KnE3	Knox silt loam, 14 to 30 percent slopes, severely eroded	26	VIe-4	4
LaB	Ladoga silt loam, 2 to 5 percent slopes	27	IIe-4	5
LaC	Ladoga silt loam, 5 to 9 percent slopes	28	IIIe-4	4
Le	Leta silty clay	28	IIw-2	6
LnE	Lindley loam, 14 to 30 percent slopes	29	VIe-4	1
LrE3	Lindley clay loam, 14 to 30 percent slopes, severely eroded	30	VIIe-7	1
LsC	Lindley and Keswick loams, 5 to 9 percent slopes	30	IIIe-4	1
LsD	Lindley and Keswick loams, 9 to 14 percent slopes	30	IVe-4	1
LwD3	Lindley and Keswick clay loams, 9 to 14 percent slopes, severely eroded	31	VIe-7	1
MaC	Mandeville silt loam, 5 to 9 percent slopes	32	IIIe-4	2
MaD	Mandeville silt loam, 9 to 14 percent slopes	32	IVe-4	2
MaE	Mandeville silt loam, 14 to 30 percent slopes	32	VIe-7	2
MbD3	Mandeville silty clay loam, 9 to 14 percent slopes, severely eroded	32	VIe-7	2
Mc	Marion silt loam	33	IIIw-2	7
MhB	Marshall silt loam, 2 to 5 percent slopes	34	IIe-1	5
MhC	Marshall silt loam, 5 to 9 percent slopes	34	IIIe-1	4
MkC	McGirk silt loam, 5 to 12 percent slopes	35	IIIe-2	6
MnB	Menfro silt loam, 2 to 5 percent slopes	36	IIe-1	5
MnC	Menfro silt loam, 5 to 9 percent slopes	36	IIIe-1	4
MnD	Menfro silt loam, 9 to 14 percent slopes	36	IIIe-1	4
MnD3	Menfro silt loam, 9 to 14 percent slopes, severely eroded	37	IVe-4	4
MnE	Menfro silt loam, 14 to 30 percent slopes	37	VIe-1	4
MoB	Mexico silt loam, 2 to 5 percent slopes	38	IIe-5	6
Mu	Moniteau silt loam	39	IIIw-2	7
NaB	Napier silt loam, 2 to 5 percent slopes	40	IIe-1	5
Nd	Nodaway silt loam	41	IIw-1	5
NoE	Norris-Rock land complex, 10 to 30 percent slopes	41	VIIe-8	3
PrB	Pershing silt loam, 2 to 5 percent slopes	43	IIIe-5	6
PrC	Pershing silt loam, 5 to 9 percent slopes	43	IIIe-5	6
Rw	Riverwash	43	VIIIs-1	--

Map symbol	Mapping unit	Page	Capability unit	Tree and shrub group
			Symbol	Number
Sa	Sarpy sand	44	IVs-1	1
ShB	Sharpsburg silt loam, 2 to 5 percent slopes	45	IIe-1	5
ShC	Sharpsburg silt loam, 5 to 9 percent slopes	45	IIIe-1	4
WeB	Weller silt loam, 2 to 5 percent slopes	46	IIIe-5	5
WeC	Weller silt loam, 5 to 9 percent slopes	47	IIIe-5	4
WnB	Winfield silt loam, 2 to 5 percent slopes	47	IIe-1	5
WnC	Winfield silt loam, 5 to 9 percent slopes	48	IIIe-1	4
WnD	Winfield silt loam, 9 to 14 percent slopes	48	IIIe-1	4
WnD3	Winfield silt loam, 9 to 14 percent slopes, severely eroded	48	IVe-4	4

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