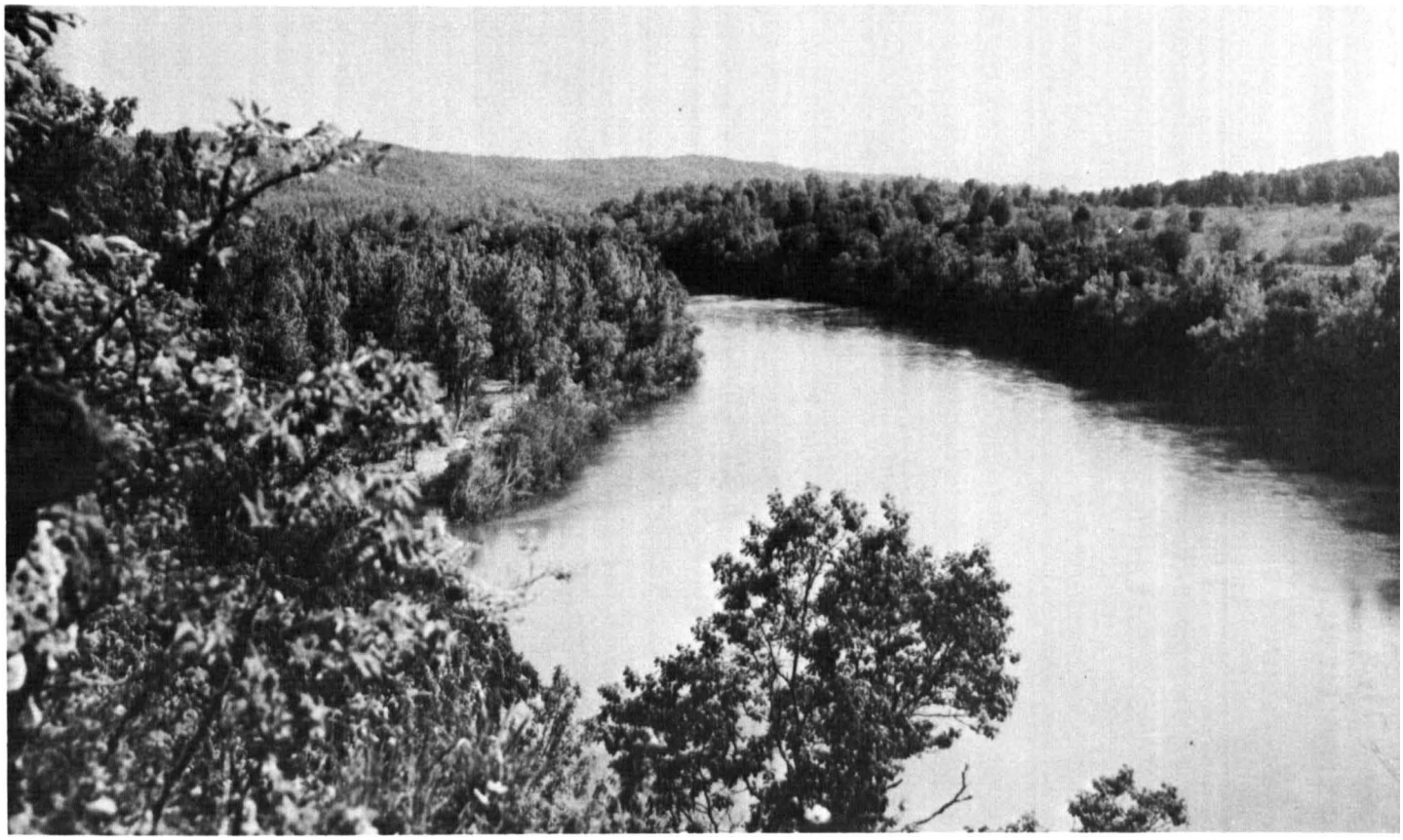
SOIL SURVEY OF

Mark Twain National Forest Area, Missouri

(Parts of Carter, Oregon, Ripley, and Shannon Counties)



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

Major fieldwork for this soil survey was done in the period 1967–70. Soil names and descriptions were approved in 1971. Unless otherwise indicated, statements in the publication refer to conditions in the area in 1970. This survey was made cooperatively by the Forest Service and Soil Conservation Service and the Missouri Agricultural Experiment Station.

Copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

All the soils in the survey area 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 area in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the capability unit in which the soil has been placed.

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

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

Foresters and others can refer to the section "Management of the Soils for Timber," where the soils of the area are grouped according to their suitability for trees.

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

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, 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."

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

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

Cover: View of the Current River near Van Buren. Clarksville and Poynor soils are on the slopes in the background, and Alluvial land, loamy, is on the bottom lands adjacent to the river.

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SOIL SURVEY OF THE MARK TWAIN NATIONAL FOREST AREA, MISSOURI (PARTS OF CARTER, OREGON, RIPLEY, AND SHANNON COUNTIES)

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

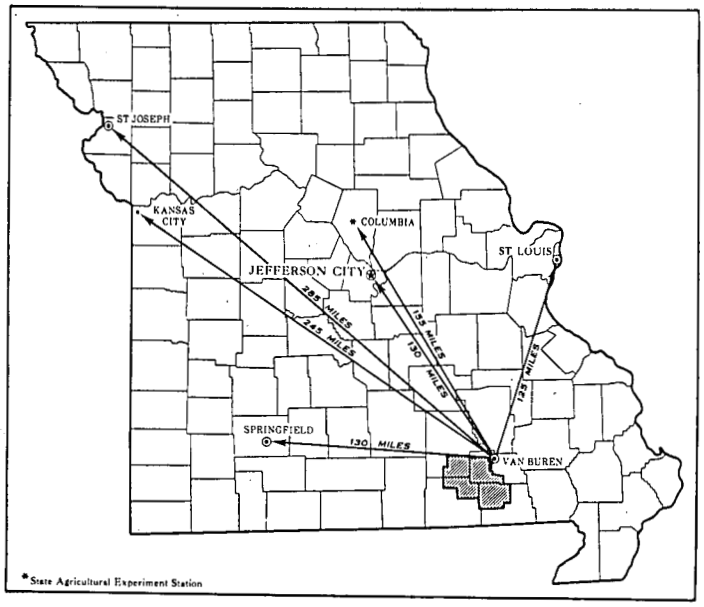

Figure 1.—Location of the Mark Twain National Forest Area in Missouri.

THE MARK TWAIN NATIONAL FOREST AREA, MISSOURI (PARTS OF CARTER, OREGON, RIPLEY, AND SHANNON COUNTIES) (called the Mark Twain National Forest Area in this soil survey) is in southeastern Missouri (fig. 1). It is located in parts of four counties: the southwestern part of Carter County, the northeastern part of Oregon County, the northwestern part of Ripley County, and the southeastern part of Shannon County. Within the survey area are the Doniphan, Van Buren, and Winona Ranger Districts. The total area is about 728 square miles, or 466,196 acres. Approximately 312,409 acres is federally administered, and 153,787 acres is privately owned. More than 80 percent of the area is forested.

Forest products are the principal source of income in the survey area. Recreation, hay and pasture, and livestock are also significant in the economy. The land area that is suited to intensive farming is limited by the steep topography and by the high chert content of the soils.

How This Survey Was Made

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

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in 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. Wilderness and Midco, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name

of a soil phase indicates a feature that affects management. For example, Doniphan cherty silt loam, 2 to 8 percent slopes, is one of several phases within the Doniphan 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 photoghaphs. 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. One such kind of mapping unit shown on the soil map of Mark Twain National Forest Area is a soil complex.

A soil complex consists of areas of two or more soils, so intricately intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Coulstone-Clarksville-Rock land complex is an example.

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 land types and are given descriptive names. Alluvial land, loamy, is a land type in this survey area.

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 a 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 Mark Twain National Forest Area. 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.

Each association is a natural pattern of soils in a landscape. Boundary lines of many associations follow the features of the underlying geologic formations. The associations are not grouped according to uses, as is done for capability classes or landsite groups.

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

The soil associations in this area are discussed in the following pages.

1. Clarksville-Coulstone association

Gently sloping to very steep soils that are cherty throughout

This association is in the northern and western parts of the survey area, in and adjacent to the Hurricane Creek watershed. The soils formed in cherty residuum (fig. 2) on narrow ridgetops and side slopes.

This association occupies 34 percent of the survey area. Clarksville soils make up 40 percent of the association; Coulstone soils 40 percent; and minor soils 20 percent.

Clarksville soils are deep and somewhat excessively drained. They have a surface layer of brown cherty silt loam and a subsoil of brownish-yellow cherty silty clay loam. Available water capacity is very low to low.

Coulstone soils are deep and somewhat excessively drained. They have a surface layer of dark-gray cherty fine sandy loam and a subsoil of brown or red cherty sandy clay loam. Available water capacity is very low to low.

Minor soils in this association are Captina and Wilderness soils on ridgetops; Poynor soils on side slopes; and

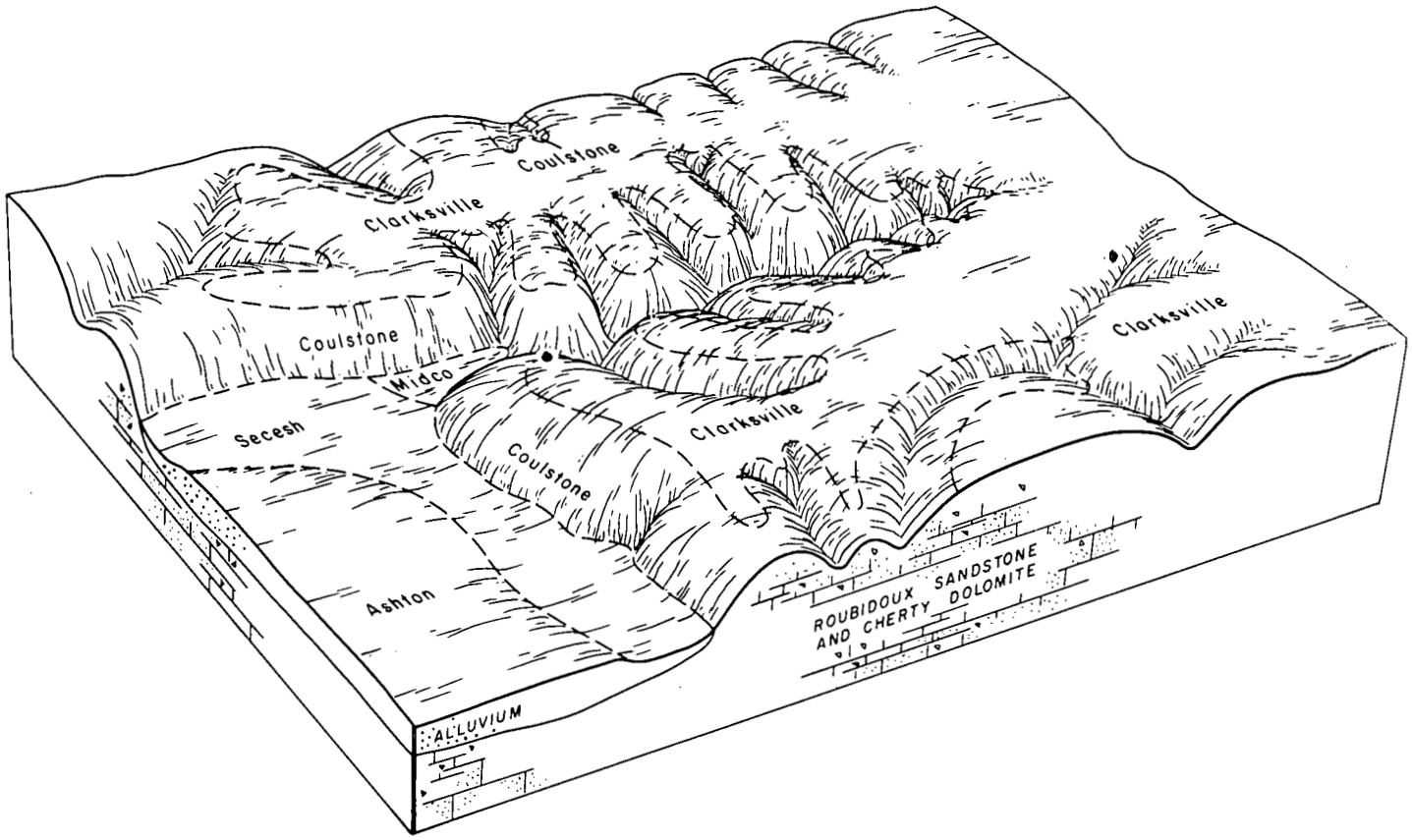

***Figure 2.*—Pattern of soils and underlying material in the Clarksville-Coulstone association.**

Ashton, Secesh, and Midco soils on bottoms along Pike Creek.

The part of this association on uplands is almost entirely forested. The bottom lands along Pike Creek are used for pasture and hay and some row crops. Droughtiness, steepness, and high chert content are the major limitations.

2. *Captina-Clarksville-Macedonia association*

Gently sloping to moderately steep soils, some of which have a fragipan, and gently sloping to very steep soils that are cherty throughout

This association is in the central, western, and eastern parts of the survey area. The soils are in broad, nearly level to gently sloping areas on ridgetops and moderately steep to very steep areas on side slopes. They formed in loess over residuum or in a mixture of loess and residuum (fig. 3).

This association occupies 28 percent of the survey area. Captina soils make up about 35 percent of the association; Clarksville soils 26 percent; Macedonia soils 20 percent; and minor soils 19 percent.

Captina soils are deep, gently sloping to moderately steep, moderately well drained soils on broad ridgetops and upper side slopes. They have a surface layer of brown silt loam and a subsoil of strong-brown silt loam and yellowish-brown silty clay loam. The lower part, below a depth of 17 to 30 inches, is a fragipan. Available water capacity is moderate to low.

Clarksville soils are deep, gently sloping to very steep, somewhat excessively drained soils on side slopes and narrow ridgetops. They have a surface layer of brown cherty silt loam and a subsoil of brownish-yellow cherty silty clay loam. Available water capacity is very low to low.

Macedonia soils are deep, gently sloping to moderately steep, well-drained soils on broad ridgetops and side slopes. They have a surface layer of dark grayish-brown silt loam and a subsoil of yellowish-brown silt loam and strong-brown cherty silty clay and silty clay. Available water capacity is moderate.

Minor soils in this association are Wilderness soils on narrow ridgetops and Coulstone soils on side slopes.

This association is used for both timber and forage. Most of the hay and pasture in the survey area is in this association. Steepness and droughtiness are the major limitations.

3. *Poynor-Macedonia-Captina association*

Gently sloping to very steep soils that have a cherty surface layer and a clayey subsoil, and gently sloping to moderately steep soils, some of which have a fragipan.

This association is in the southern and south-central parts of the survey area. The soils are mainly in gently sloping areas on ridgetops and steep areas on side slopes. They formed in loess and the underlying residuum (fig. 4).

This association occupies 21 percent of the survey area. Poynor soils make up 28 percent of the association;

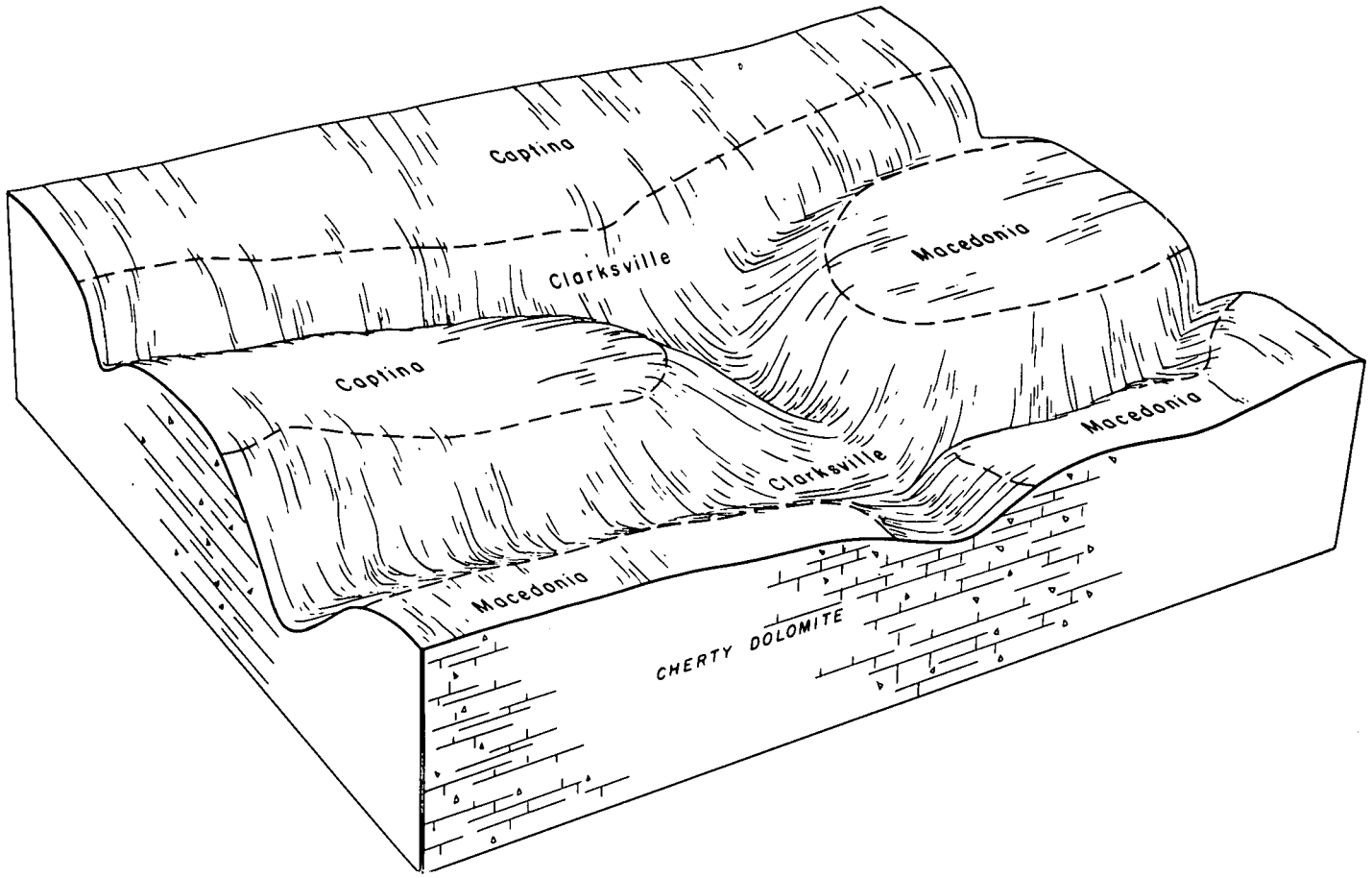

Figure 3.—**Pattern of soils and underlying material in the Captina-Clarksville-Macedonia association.**

Macedonia soils 20 percent; Captina soils 17 percent; and minor soils 35 percent.

Poynor soils are deep, gently sloping, well-drained soils on narrow ridgetops and deep, moderately steep to very steep, well-drained soils on side slopes. They have a surface layer of brown cherty silt loam and a subsoil of red silty clay or clay. Available water capacity is low to moderate.

Macedonia soils are deep, gently sloping to moderately steep, well-drained soils on the tops of broad ridges and on upper side slopes. They have a surface layer of dark grayish-brown silt loam and a subsoil of yellowish-brown silt loam, strong-brown cherty heavy silty clay, strong-brown silty clay, and strong-brown cherty clay.

Captina soils are deep, gently sloping to moderately steep, moderately well drained soils. They have a surface layer of brown silt loam, a subsoil of strong-brown silt loam and yellowish-brown silty clay loam, and a fragipan at a depth of 17 to 30 inches. Available water capacity is moderate to low.

Minor soils in this association are Wilderness soils on the tops of narrow ridges, Doniphan soils on the tops of broad ridges, and Clarksville soils on side slopes.

Most of this association is forested. Some areas along the drainageways have been cleared and are used for farming. Steepness and droughtiness are the major limitations.

4. Clarksville-Poynor-Doniphan association

Gently sloping to very steep soils that have a cherty surface layer and a cherty or clayey subsoil

This association is in the eastern part of the survey area along the Current River. The soils formed in cherty, clayey residuum (fig. 5), mainly on either long and narrow or broad and gently sloping ridges.

This association occupies 17 percent of the survey area. Clarksville soils make up 40 percent of it; Poynor soils 20 percent; Doniphan soils 15 percent; and minor soils 25 percent.

Clarksville soils are deep, gently sloping to very steep, somewhat excessively drained soils on side slopes and narrow ridgetops. They have a surface layer of brown cherty silt loam and a subsoil of brownish-yellow cherty silty clay loam. Available water capacity is very low to low.

Poynor soils are deep, gently sloping, well-drained soils on the tops of narrow ridges and deep, moderately steep to very steep, well-drained soils on side slopes. They have a surface layer of brown cherty silt loam and a subsoil of red silty clay or clay. Available water capacity is low to moderate.

Doniphan soils are deep, gently sloping to steep, well-drained soils on the tops of ridges and on side slopes. They have a surface layer of brown cherty silt loam and

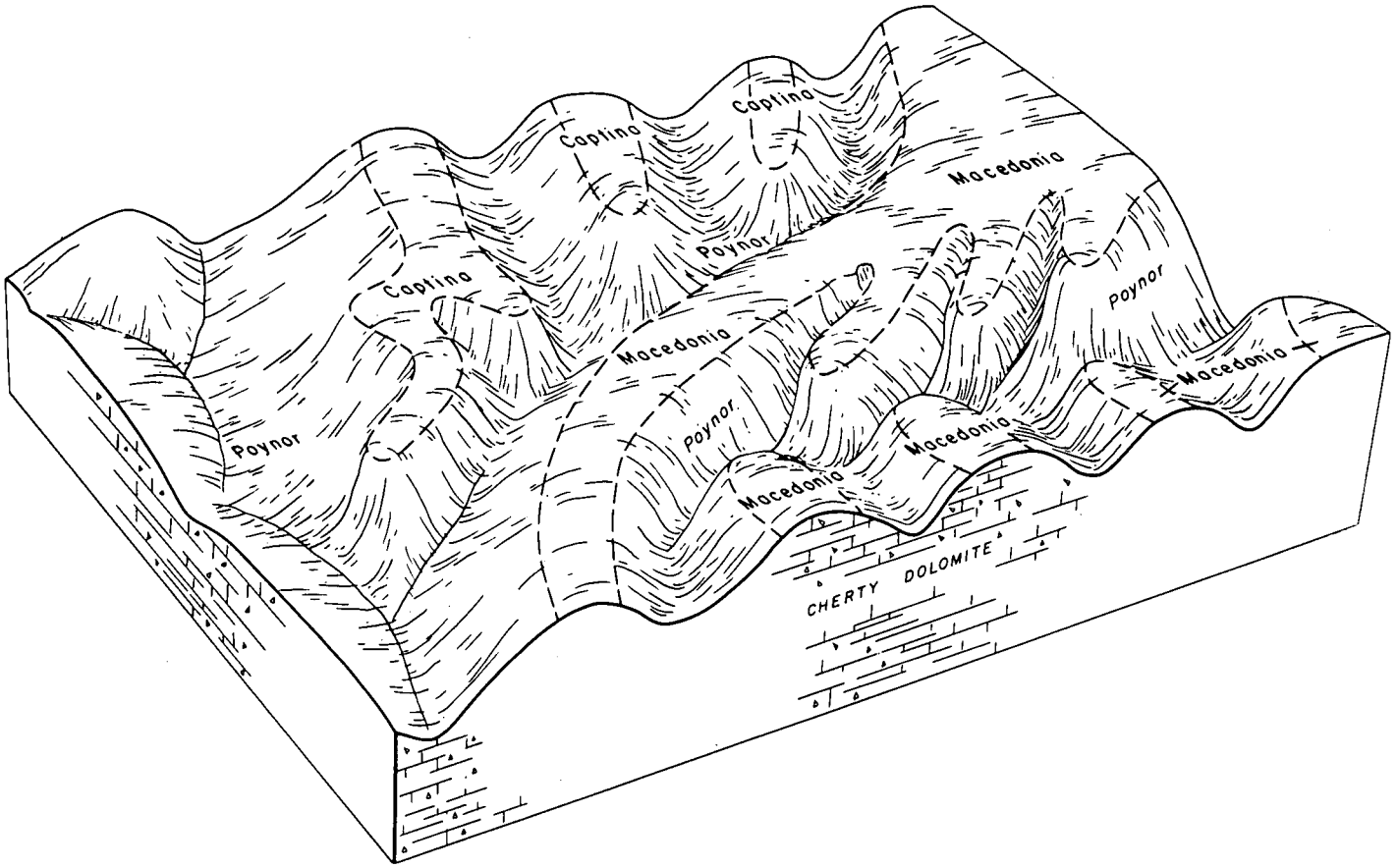

Figure 4.—**Pattern of soils and underlying material in the Poynor-Macedonia-Captina association.**

a subsoil of red, mottled clay. Available water capacity is moderate.

Minor soils in this association are the Secesh, Ashton, and Midco soils on bottom lands along the Current River. Small acreages of other minor soils are scattered throughout the association.

Most of this association is forested. The bottom lands are used for crops and pasture. Steepness and droughtiness are the major limitations.

Descriptions of the Soils

This section describes the soil series and mapping units in the survey area. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed 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. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for moist soil unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Alluvial land, loamy, and Rock land, for example, do not belong to a soil series, but nevertheless, are listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, land-site group, and woodland suitability group in which the mapping unit has been placed. The page on which each interpretive group is described can be found 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

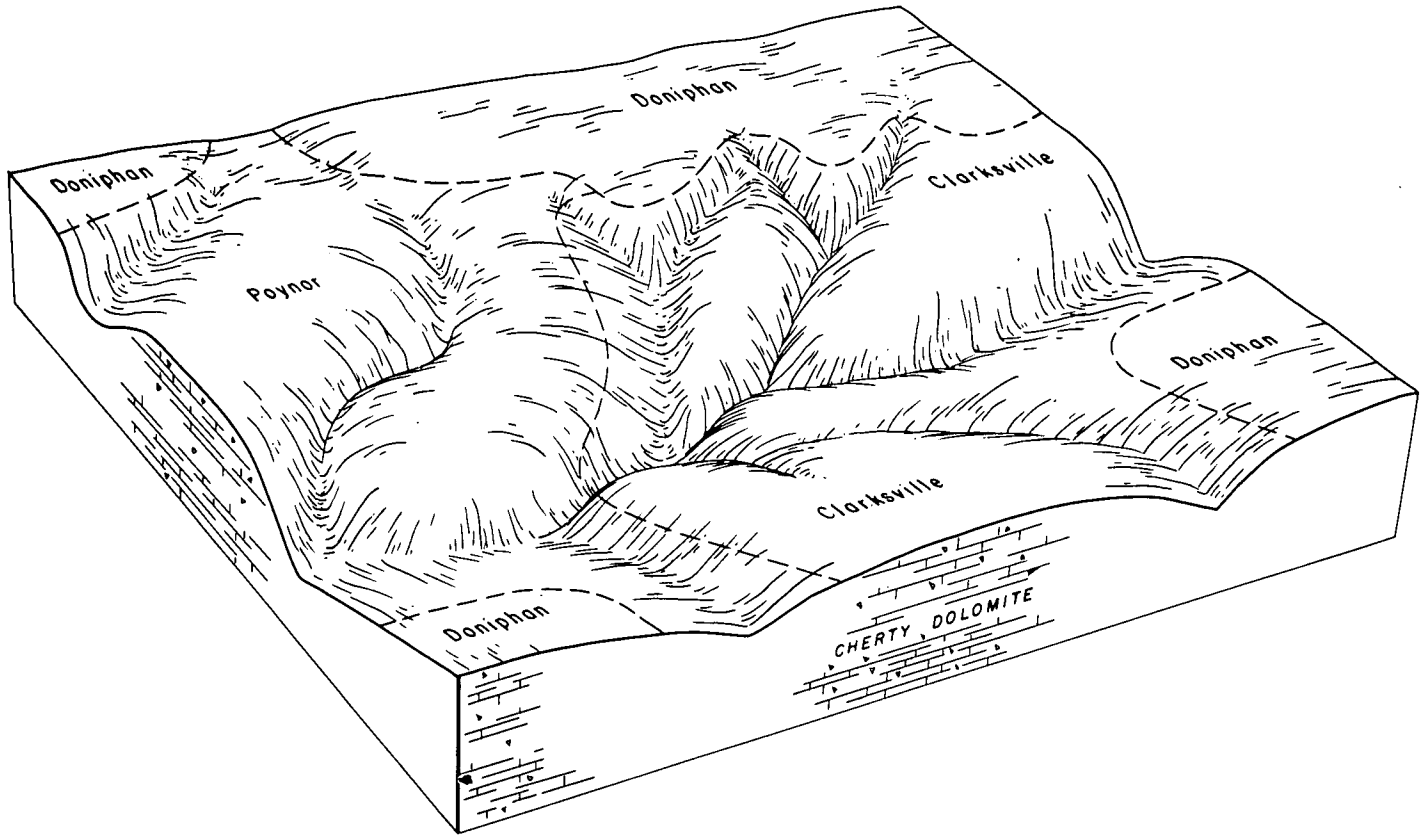

Figure 5.—**Pattern of soils and underlying material in the Clarksville-Poynor-Doniphan association.**

of soil mapping can be obtained from the Soil Survey Manual (*6*).[1]

The names of some soils are unlike those appearing on recently published surveys in adjacent counties because of change in the concepts of soil series and in the application of the soil classification system. For some series, the profile selected as representative has one or more features outside the defined range of characteristics. In these instances, a reference is made to explain how the soil differs from the allowed range for the series. Unless otherwise stated, the profiles have characteristics that are within the defined range of the series.

Alluvial Land

This miscellaneous land type is made up of areas of alluvium recently deposited on first and second bottoms and along the major streams throughout the survey area. These soils are subject to flooding.

Alluvial land, loamy (Aa).—The areas of this land type formed in recent sandy alluvium that is underlain by silt, gravel, or coarse sand. Depth to the underlying material ranges from 20 to 60 inches.

Included with this land type in mapping are small areas of Midco and Secesh soils.

This land type is suited to esthetic purposes, such as a site for screening vegetation along rivers. Some of the higher areas are suited to small, primitive camping or picnic areas. Flooding and droughtiness are the major limitations. Capability unit IVs–1; not placed in a landsite group or woodland suitability group.

Alluvial land, mixed (Am).—This land type is a combination of riverwash materials along the stream, stratified sand and gravel, and severely channeled areas away from the stream in old channels.

Where the dominant material in this land type is riverwash, the vegetation generally is sparse and consists of willows and a few small sycamore trees. In other areas the vegetation is a lush growth of black oak, sycamore, elm, and walnut trees and an understory of willows and cane (fig. 6).

This land is subject to frequent annual flooding because of its position. There is frequent deposition of new materials and a mixing of the material already present. Drainage is variable, and shallow pools are common.

The screening effect and the esthetic appeal of these areas along the river give this soil a high recreational value. Gravel bars are commonly used as campsites by fishermen and others. The areas are also natural travel lanes for wildlife living along the waterways. Capability unit Ve–15; not placed in a landsite group or woodland suitability group.

Ashton Series

The Ashton series consists of deep, nearly level or gently sloping, well-drained soils. These soils formed in alluvium on low stream terraces.

[1] Italic numbers in parentheses refer to Literature Cited, p. 53.

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

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Alluvial land, loamy	1, 300	0. 3	Doniphan cherty silt loam, 2 to 8 percent slopes	16, 600	3. 6
Alluvial land, mixed	3, 000	. 6	Doniphan cherty silt loam, 8 to 14 percent slopes	3, 400	. 7
Ashton silt loam, 1 to 4 percent slopes	7, 100	1. 5	Doniphan cherty silt loam, 14 to 35 percent slopes	760	. 2
Captina silt loam, 2 to 8 percent slopes	48, 000	10. 0	Macedonia silt loam, 2 to 8 percent slopes	46, 250	9. 9
Captina silt loam, moderately shallow, 2 to 8 percent slopes	20, 000	4. 3	Macedonia silt loam, 8 to 14 percent slopes	3, 500	. 8
Captina silt loam, moderately shallow, 8 to 14 percent slopes	1, 700	. 4	Midco cherty loam, 1 to 4 percent slopes	38, 000	8. 2
Claiborne silt loam, 2 to 8 percent slopes	2, 350	. 5	Newark silt loam, 0 to 2 percent slopes	970	. 2
Claiborne silt loam, 8 to 14 percent slopes	620	. 1	Opequon rocky silty clay loam, 8 to 14 percent slopes	740	. 2
Clarksville cherty silt loam, 2 to 8 percent slopes	38, 250	8. 3	Opequon rocky silty clay loam, 14 to 35 percent slopes	1, 400	. 3
Clarksville cherty silt loam, 8 to 14 percent slopes	24, 750	5. 3	Opequon rocky silty clay loam, 35 to 60 percent slopes	700	. 2
Clarksville cherty silt loam, 14 to 35 percent slopes	53, 500	11. 5	Poynor cherty silt loam, 2 to 8 percent slopes	12, 500	2. 7
Clarksville cherty silt loam, 35 to 60 percent slopes	15, 400	3. 3	Poynor cherty silt loam, 8 to 14 percent slopes	12, 900	2. 8
Coulstone cherty fine sandy loam, 2 to 8 percent slopes	12, 700	2. 7	Poynor cherty silt loam, 14 to 35 percent slopes	23, 750	5. 1
Coulstone cherty fine sandy loam, 8 to 14 percent slopes	8, 300	1. 8	Poyner cherty silt loam, 35 to 60 percent slopes	2, 200	. 5
Coulstone cherty fine sandy loam, 14 to 35 percent slopes	37, 000	7. 9	Rock land, 8 to 14 percent slopes	780	. 2
Coulstone cherty fine sandy loam, 35 to 60 percent slopes	5, 800	1. 2	Rock land, 14 to 35 percent slopes	1, 500	. 3
Coulstone-Clarksville-Rock land complex, 8 to 14 percent slopes	253	. 1	Rock land, 35 to 60 percent slopes	2, 450	. 5
Coulstone-Clarksville-Rock land complex, 14 to 35 percent slopes	423	. 1	Secesh loam, 1 to 4 percent slopes	6, 200	1. 3
Coulstone-Clarksville-Rock land complex, 35 to 60 percent slopes	1, 500	. 3	Viraton silt loam, 2 to 8 percent slopes	1, 750	. 4
			Wilderness cherty silt loam, 2 to 8 percent slopes	6, 300	1. 4
			Wilderness cherty silt loam, 8 to 14 percent slopes	1, 150	. 2
			Water area	450	. 1
			Total	466, 196	100. 0

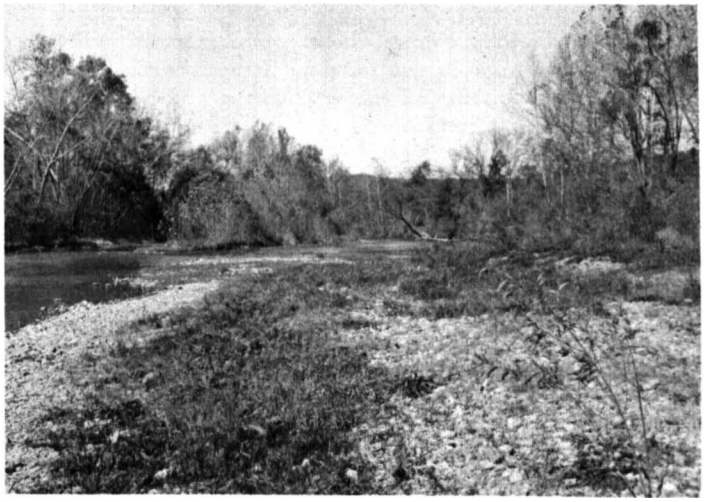

***Figure 6.*—Area of Alluvial land, mixed, along the Eleven Point River.**

In a representative profile the surface layer is dark-brown silt loam about 8 inches thick. The transition layer is dark yellowish-brown silt loam about 8 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper part of the subsoil is dark-brown, friable silt loam, and the lower part is dark-brown silt loam that has faint, brown mottles.

Permeability is moderate. Available water capacity is high. Natural fertility is moderately high.

Most areas of these soils are used for cultivated crops, pasture, and timber. A few areas are used for recreational facilities. These are the best soils in the survey area for the production of cultivated crops and high-value timber.

Representative profile of Ashton silt loam, 1 to 4 percent slopes, NE¼NW¼ sec. 4, T. 25 N., R. 3 W.:

Ap—0 to 8 inches, dark-brown (10YR 3/3) silt loam; weak, fine, granular structure; friable; many roots; slightly acid; abrupt, smooth boundary.

A&B—8 to 16 inches, dark yellowish-brown (10YR 3/4) silt loam; weak, fine, subangular blocky structure; friable; common roots; slightly acid; gradual, wavy boundary.

B21t—16 to 36 inches, dark-brown (7.5YR 4/4) heavy silt loam; weak, fine, subangular blocky structure; friable; faint patchy clay films on peds; common roots; slightly acid; gadual, wavy boundary.

B22t—36 to 60 inches, dark-brown (7.5YR 4/4) silt loam that has common, fine, faint, brown (10YR 5/3) mottles; weak, fine, subangular blocky structure; friable; distinct patchy clay films on peds; few roots; slightly acid.

The solum ranges from 40 inches to more than 60 inches in thickness. The Ap horizon is dark brown to dark yellowish brown. The B horizon is brown to dark yellowish brown.

Ashton soils are associated with Secesh and Newark soils. They contain less chert and gravel than Secesh soils and are better drained than Newark soils.

Ashton silt loam, 1 to 4 percent slopes (AtB).—This soil is on low stream terraces in wide stream valleys. Areas of this soil are irregular in shape and range from 5 to 30 acres in size.

Included with this soil in mapping are a few small areas of Secesh and Newark soils.

This is the best soil in the survey area for cultivated crops and for the production of high-value timber. This soil is well suited to wildlife habitat. Surface runoff is slow or medium. Flooding in areas along the major drainageways is the major limitation. Capability unit I-1; landsite group A; woodland suitability group 3o7.

Captina Series

The Captina series consists of deep, gently sloping to moderately steep, moderately well drained soils that have a fragipan. These soils are on tops of ridges and on the upper part of side slopes. They formed in loess and in the underlying cherty limestone residuum.

In a representative profile the surface layer is dark yellowish-brown silt loam about 5 inches thick. The subsoil is strong-brown silt loam in the upper 11 inches and yellowish-brown silty clay loam in the next 12 inches. Below this is a fragipan that is gray silty clay loam in the upper 4 inches and yellowish-brown cherty silty clay loam in the lower part, which extends to a depth of 60 inches.

Permeability is moderate in the upper layers and slow in the fragipan. Available water capacity is moderate to low. Natural fertility is low.

Most areas of these soils are forested. Some areas have been cleared and are used for hay and pasture.

Representative profile of Captina silt loam, 2 to 8 percent slopes, NE¼NE¼ sec. 17, T. 24 N., R. 2 E.:

A1—0 to 5 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, fine, granular structure; firm; many roots; slightly acid; abrupt, smooth boundary.

B1—5 to 16 inches, strong-brown (7.5YR 5/6) silt loam; moderate, medium, subangular blocky structure; firm; common roots; medium acid; clear, wavy boundary.

B21t—16 to 20 inches, yellowish-brown (10YR 5/6) silty clay loam; strong, medium, subangular blocky structure; firm; distinct broken clay films on ped faces; common roots; medium acid; clear, wavy boundary.

B22t—20 to 28 inches, yellowish-brown (10YR 5/6) silty clay loam that has few, fine, distinct, brown (7.5YR 5/4), strong-brown (7.5YR 5/6), and gray (10YR 5/1) mottles; strong, medium, subangular blocky structure; firm; distinct broken clay films on ped faces; estimated 5 percent chert; common roots; strongly acid; clear, wavy boundary.

IIAx—28 to 32 inches, gray (10YR 5/1) silty clay loam that has yellowish-brown (10YR 5/6 and 5/4) mottles; strong, medium, subangular blocky structure; firm and brittle; estimated 10 percent chert; roots in cracks; strongly acid; abrupt, wavy boundary.

IIBx1—32 to 39 inches, yellowish-brown (10YR 5/6) cherty silty clay loam that has red (2.5YR 4/6) and gray (10YR 5/1) mottles; weak, fine, subangular blocky structure; firm and brittle; estimated 50 percent chert; few roots in cracks; strongly acid; clear, wavy boundary.

IIBx2—39 to 60 inches, yellowish-brown (10YR 5/6) cherty silty clay loam that has gray (10YR 5/1) mottles; moderate, medium, subangular blocky structure; firm and brittle; estimated 50 percent chert; strongly acid.

The A horizon ranges from dark grayish brown to brown in color and from 0 to 10 percent in chert content. Reaction is strongly acid to slightly acid. The B horizon ranges from yellowish brown to strong brown in color and from 0 to 10 percent in chert content. Reaction is very strongly acid to medium acid. Depth to the fragipan ranges from 17 to 30 inches. Colors of the fragipan are shades of gray, brown, and red, and mottled patterns are common. The IIBx horizon has a chert content of 35 to 80 percent. Reaction is very strongly acid to strongly acid.

Captina soils are associated with Wilderness and Macedonia soils. They have less chert in the profile than Wilderness soils. They have a fragipan, which Macedonia soils lack.

Captina silt loam, 2 to 8 percent slopes (CaB).—This soil is on the tops of broad ridges. It has the profile described as representative for the series.

Included with this soil in mapping are areas of Macedonia soils and areas of the moderately shallow Captina soils.

This soil is suited to timber production, to hay and pasture, to small grain, and to use as wildlife habitat. Surface runoff is medium. The fragipan, which restricts the rooting zone of some plants, and seasonal wetness are the major limitations. Capability unit IIe-5; landsite group B, woodland suitability group 4o7.

Captina silt loam, moderately shallow, 2 to 8 percent slopes (CbB).—This soil is on the tops of broad ridges. It has a profile similar to that described as representative for the series, but it has a fragipan at a shallower depth.

Included with this soil in mapping are a few areas of Macedonia and Wilderness soils.

This soil is suited to timber production, to hay and pasture, to small grain, and to use as wildlife habitat. Surface runoff is medium. The fragipan, which restricts the rooting zone of some plants, and, in some areas, seasonal wetness are the major limitations. Capability unit IIe-5; landsite group B; woodland suitability group 4o7.

Captina silt loam, moderately shallow, 8 to 14 percent slopes (CbD).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has more chert in the surface layer and has a fragipan at a shallower depth. Chert fragments cover 5 to 15 percent of the surface.

Included with this soil in mapping are areas of Wilderness and Clarksville soils.

This soil is suited to timber production, to hay and pasture, and to use as wildlife habitat. Surface runoff is medium. The fragipan, which restricts the rooting zone of some plants, is the major limitation. Capability unit IIIe-5; landsite group B; woodland suitability group 4o7.

Claiborne Series

The Claiborne series consists of deep, gently sloping to moderately steep, well-drained soils. These soils formed in colluvium on toe slopes at the foot of slopes and ridge ends. Areas are commonly less than 10 acres in size.

In a representative profile the surface layer is dark grayish-brown silt loam about 3 inches thick. The subsurface layer is yellowish-brown silt loam about 4 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper part of the subsoil is dark yellowish-brown, friable silt loam 6 inches thick; the middle part is strong-brown or brown, firm silty clay loam 21 inches thick; and the lower part is faintly mottled, yellowish-red or red silty clay loam.

Permeability is moderate. Available water capacity is high. Natural fertility is medium.

These soils are used for timber production and for hay and pasture.

Representative profile of Claiborne silt loam, 2 to 8 percent slopes, about 250 feet north of Forest Service Road 3146, SE¼NE¼ sec. 1, T. 25 N., R. W.:

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

A2—3 to 7 inches, yellowish-brown (10YR 5/4) silt loam; moderate, medium, granular structure; friable; many roots; very strongly acid; clear, wavy boundary.

B1—7 to 13 inches, dark yellowish-brown (10YR 4/4) silt loam; moderate, medium, subangular blocky structure; friable; common roots; very strongly acid; clear, wavy boundary.

B21t—13 to 22 inches, strong-brown (7.5YR 5/6) silty clay loam; moderate, medium, subangular blocky structure; firm; thin patchy clay films; common roots; strongly acid; gradual, wavy boundary.

B22t—22 to 34 inches, brown (7.5YR 4/4) silty clay loam; moderate, medium, subangular blocky structure; firm; thin continuous clay films; common roots; strongly acid; abrupt, wavy boundary.

B23t—34 to 42 inches, yellowish-red (5YR 4/8) silty clay loam that has few, fine, faint, yellowish-red (5YR 4/6 and 5/8) mottles; moderate, medium, subangular blocky structure; firm; thin continuous clay films on peds; few roots; strongly acid; gradual, wavy boundary.

B24t—42 to 58 inches, red (2.5YR 4/8) silty clay loam that has few, fine, faint, yellowish-red (5YR 4/6 and 5/8) and strong-brown (7.5YR 4/6) mottles; moderate, medium, subangular blocky structure; firm; thin continuous clay films; few chert fragments; few roots; strongly acid; gradual, smooth boundary.

B3t—58 to 66 inches, red (2.5YR 4/6) light silty clay loam that has few, fine, faint, yellowish-red (5YR 4/6 and 5/8) and strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; firm; thin, patchy, weak-red clay films on ped faces; few chert fragments; few roots; strongly acid.

The solum ranges from 40 inches to more than 70 inches in thickness. Depth to bedrock ranges from 10 to 30 feet. The A1 horizon is very dark brown to dark grayish-brown silt loam or light silty clay loam 3 to 8 inches thick. The A2 horizon is yellowish-brown or brown silt loam or light silty clay loam. In some places there is an Ap horizon that is brown, yellowish-brown, or strong-brown silt loam. The B horizon is 36 inches to more than 60 inches thick. The upper part ranges from dark yellowish-brown to brown silt loam or silty clay loam, and the lower part is yellowish-red or red silty clay loam. Reaction ranges from medium acid to very strongly acid throughout the profile. Many profiles have a B horizon in which iron and manganese concretions or coatings are on the peds.

Claiborne soils are associated with Clarksville and Poynor soils. They contain less chert in the profile than Clarksville and Poynor soils.

Claiborne silt loam, 2 to 8 percent slopes (CcB).—This soil is in long and narrow or irregularly shaped areas of colluvium near drainageways or on bottom lands. It has the profile described as representative for the series. Areas are commonly less than 10 acres in size.

Included with this soil in mapping are a few areas of soils where the surface layer contains more chert than is typical for this Claiborne soil.

This soil is well suited to production of high-value timber, to pasture and hay, to small grain, and to use as wildlife habitat. Capability unit IIe–1; landsite group A; woodland suitability group 3o7.

Claiborne silt loam, 8 to 14 percent slopes (CcD).—This soil is in long, narrow areas of colluvium near drainageways. It has a profile similar to that described as representative for the series, but it has more chert in the surface layer. Areas are commonly less than 10 acres in size.

Included with this soil in mapping are a few areas of soils that have a loam surface layer.

This soil is well suited to production of high-value timber, to pasture and hay, and to use as wildlife habitat. Surface runoff is medium. The hazard of erosion is moderate. Capability unit IVe–1; landsite group A; woodland suitability group 3o7.

Clarksville Series

The Clarksville series consists of deep, somewhat excessively drained soils. These soils are gently sloping on the tops of narrow ridges and moderately steep to very steep on side slopes. They formed in material weathered from cherty dolomite.

In a representative profile the surface layer is brown cherty silt loam about 3 inches thick. The subsurface layer is pale-brown cherty silt loam 4 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper part is brownish-yellow, firm cherty silt loam; the middle part is strong-brown, very firm cherty silty clay loam; and the lower part is strong-brown and yellowish-red, very firm cherty silty clay loam.

Permeability is moderate to rapid. Available water capacity is very low to low. Natural fertility is low. These soils are used for timber production. They provide food and cover for wildlife.

Representative profile of Clarksville cherty silt loam, 14 to 35 percent slopes, NE¼NW¼ sec. 22, T. 26 N., R. 2 W.:

A1—0 to 3 inches, brown (10YR 4/3) cherty silt loam; weak, very fine, granular structure; loose; estimated 50 percent chert less than 6 inches in diameter; many roots; medium acid; clear, wavy boundary.

A2—3 to 7 inches, pale-brown (10YR 6/3) cherty silt loam; weak, fine, subangular blocky structure; friable; estimated 40 percent chert less than 6 inches in diameter; many roots; medium acid; clear, wavy boundary.

B1—7 to 13 inches, brownish-yellow (10YR 6/6) cherty silt loam; weak, fine, subangular blocky structure; firm; estimated 40 percent chert less than 6 inches in diameter; many roots; strongly acid; clear, wavy boundary.

B21t—13 to 26 inches, strong-brown (7.5YR 5/6) cherty silty clay loam; moderate, fine, subangular blocky structure; very firm; estimated 70 percent chert less than 6 inches in diameter; common roots; strongly acid; gradual, wavy boundary.

B22t—26 to 36 inches, strong-brown (7.5YR 5/6) cherty heavy silty clay loam; moderate, fine, subangular blocky structure; very firm; estimated 40 percent chert less than 6 inches in diameter; common roots; very strongly acid; gradual, wavy boundary.

B23t—36 to 60 inches, strong-brown (7.5YR 5/6) and yellowish-red (5YR 5/6) cherty silty clay loam; weak, fine and medium, subangular blocky structure; very firm; faint patchy clay films on peds; estimated 40 percent chert less than 6 inches in diameter; few roots; very strongly acid.

The A horizon ranges from brown to light brownish gray in color and from 20 to 50 percent in chert content. The B horizon ranges from brownish yellow to yellowish red in color and from 20 to 75 percent in chert content. Large fragments of chert are throughout the profile. Reaction ranges from very strongly acid to medium acid throughout the profile.

Clarksville soils are associated with Poynor and Coulstone soils. They are less clayey in the subsoil than Poynor soils and less sandy than Coulstone soils.

Clarksville cherty silt loam, 2 to 8 percent slopes (CdB).—This soil is on the tops of narrow ridges. It has a profile similar to that described as representative for the series, but it has less chert both in the profile and on the surface. Chert fragments cover from 15 to 35 percent of the surface.

Included with this soil in mapping are a few small areas of Coulstone, Wilderness, Captina, and Poynor soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness and high chert content are major limitations of this soil for farming. Capability unit IVs-9; landsite groups B and C; woodland suitability group 5f7.

Clarksville cherty silt loam, 8 to 14 percent slopes (CdD).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has less chert on the surface. Chert fragments cover from 25 to 35 percent of the surface.

Included with this soil in mapping are a few small areas of Coulstone and Poynor soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and high chert content are the major limitations. Capability unit VIs-9; landsite groups B and C; woodland suitability groups 4f8 and 5f7.

Clarksville cherty silt loam, 14 to 35 percent slopes (CdE).—This soil is on side slopes. It has the profile described as representative for the series. Chert fragments cover from 25 to 50 percent of the surface.

Included with this soil in mapping are a few small areas of Coulstone and Poynor soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and high chert content are the major limitations. Capability unit VIIs-9; landsite groups B and C; woodland suitability groups 4f9 and 5f9.

Clarksville cherty silt loam, 35 to 60 percent slopes (CdF).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has a thinner surface layer. Chert fragments cover as much as 50 percent of the surface. Many large boulders are an the surface.

Included with this soil in mapping are areas of Poynor, Coulstone, and Rock land.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and high chert content are the major limitations. Capability unit VIIs-9; landsite groups B and C; woodland suitability groups 4f9 and 5f9.

Coulstone Series

The Coulstone series consists of deep, cherty, somewhat excessively drained soils. These soils are gently sloping on the tops of narrow ridges and moderately steep to very steep on side slopes in the highly dissected areas. They formed in material weathered from dolomite and sandstone.

In a representative profile the surface layer is dark-gray cherty fine sandy loam about 7 inches thick. The subsurface layer is yellowish-brown cherty fine sandy loam about 12 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper part of the subsoil is yellowish-brown, friable cherty sandy clay loam; the middle part is strong-brown, friable cherty sandy clay loam that has many large fragments of sandstone; and the lower part is red, yellowish-red, and strong-brown, firm cherty clay.

Permeability is moderate to rapid. Available water capacity is very low to low. Natural fertility is low.

These soils are used for timber production, particularly shortleaf pine. They provide food and cover for wildlife.

Representative profile of Coulstone cherty fine sandy loam, 14 to 35 percent slopes, NW¼SE¼ sec. 36, T. 27 N., R. 3 W.:

A1—0 to 7 inches, dark-gray (10YR 4/1) cherty fine sandy loam; weak, fine, granular structure; friable; estimated 35 percent chert; many roots; strongly acid; clear, wavy boundary.

A21—7 to 11 inches, light yellowish-brown (10YR 6/4) cherty fine sandy loam; weak, fine, granular structure; friable; estimated 30 percent chert; many roots; strongly acid; clear, wavy boundary.

A22—11 to 19 inches, yellowish-brown (10YR 5/4) cherty fine sandy loam; weak, fine, granular structure; friable; estimated 40 percent chert; common roots; very strongly acid; clear, wavy boundary.

A&B—19 to 26 inches, yellowish-brown (10YR 5/6) cherty sandy clay loam; weak, fine, subangular blocky structure; friable; estimated 50 percent chert; common roots; very strongly acid; clear, wavy boundary.

B21t—26 to 40 inches, strong-brown (7.5YR 5/8) cherty sandy clay loam; weak, fine, subangular blocky structure; friable; estimated 75 percent chert, including many pieces of sandstone 6 to 15 inches in diameter; very strongly acid; clear, wavy boundary.

B22t—40 to 60 inches, mottled red (2.5YR 4/8), yellowish-red (5YR 5/6), and strong-brown (7.5YR 5/6) cherty clay; moderate, fine, subangular blocky structure; firm; faint patchy clay films on peds; estimated 25 percent chert; few roots; very strongly acid.

The A horizon ranges from dark brown to light yellowish brown in color and from 20 to 50 percent in chert content. The B horizon is yellowish brown to strong brown in the upper part and strong brown to red in the lower part. Chert content ranges from 20 to 75 percent. Large fragments of chert and sandstone are throughout the profile. Reaction ranges from very strongly acid to medium acid throughout the profile.

Coulstone soils are associated with Clarksville and Poynor soils. They have more sand in the profile than Clarksville and Poynor soils.

Coulstone cherty fine sandy loam, 2 to 8 percent slopes (ChB).—This soil is on the tops of narrow ridges. It has a profile similar to that described as representative for the series, but it has slightly less chert in the profile and on the surface. Chert fragments cover from 10 to 25 percent of the surface.

Included with this soil in mapping are a few small areas of Clarksville, Wilderness, and Poynor soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness and high chert content are the major limitations. Capability unit IVs-9; landsite group C; woodland suitability group 5f7.

Coulstone cherty fine sandy loam, 8 to 14 percent slopes (ChD).—This soil is on side slopes. It has a profile similar to that described as representative for the series,

except that it has slightly less chert on the surface. Chert fragments cover from 25 to 35 percent of the surface.

Included with this soil in mapping are a few small areas of Clarksville and Poynor soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and high chert content are the major limitations. Capability unit VIs–9; landsite groups B and C; woodland suitability groups 4f8 and 5f7.

Coulstone cherty fine sandy loam, 14 to 35 percent slopes (ChE).—This soil is on side slopes. It has the profile described as representative for the series. Chert fragments cover from 25 to 50 percent of the surface. Large boulders and sandstone fragments are on the surface.

Included with this soil in mapping are a few small areas of Clarksville and Poynor soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and high chert content are the major limitations. Capability unit VIIs–9; landsite groups B and C; woodland suitability groups 4f9 and 5f9.

Coulstone cherty fine sandy loam, 35 to 60 percent slopes (ChF).—This soil is on side slopes. It has a profile similar to that described as representative for the series. but it has more chert and boulders on the surface, and the surface layer is slightly thinner. Chert fragments cover as much as 50 percent of the surface. Many large boulders and sandstone fragments are on the surface.

Included with this soil in mapping are areas of Clarksville soils that make up as much as 40 percent of areas mapped as this Coulstone soil. Also included are some small areas of Rock land.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and high chert content are the major limitations. Capability unit VIIs–9; landsite groups B and C; woodland suitability groups 4f9 and 5f9.

Coulstone-Clarksville-Rock land complex, 8 to 14 percent slopes (CvD).—The soils of this complex are on side slopes. About 40 percent of the area is Coulstone cherty fine sandy loam; 40 percent is Clarksville cherty silt loam; and 20 percent is Rock land. The Coulstone and Clarksville soils have profiles similar to those described as representative for their respective series. Chert fragments cover about 25 to 40 percent of the surface.

Areas of this mapping unit have a cover of redcedar, oak, and pine. These areas are suited to timber production and to use as wildlife habitat. Surface runoff is medium. Steepness and chert content are the major limitations. Capability unit VIs–9; not placed in a landsite group or woodland suitability group.

Coulstone-Clarksville-Rock land complex, 14 to 35 percent slopes (CvE).—The soils of this complex are on side slopes. About 50 percent of the area is Coulstone cherty fine sandy loam; 30 percent is Clarksville cherty silt loam; and 20 percent is Rock land. The Coulstone and Clarksville soils have profiles similar to those described as representative for their respective series. Chert fragments cover about 35 to 50 percent of the surface. Many large sandstone boulders are on the surface.

Areas of this mapping unit have a cover of redcedar, oak, and pine. These areas are suited to timber production and to use as wildlife habitat. Surface runoff is medium to rapid. Steepness and chert content are the major limitations. Capability unit VIIs–9; not placed in a landsite group or woodland suitability group.

Coulstone-Clarksville-Rock land complex, 35 to 60 percent slopes (CvF).—The soils of this complex are on side slopes. About 50 percent of the area is Coulstone cherty fine sandy loam; 30 percent is Clarksville cherty silt loam; and 20 percent is Rock land. The Coulstone and Clarksville soils have profiles similar to those described as representative for their respective series. Chert fragments cover from 35 to 60 percent of the surface. Many large sandstone boulders are on the surface.

Areas of this mapping unit have a cover of redcedar, oak, and pine. The soils are suited to timber production and to use as wildlife habitat. Surface runoff is medium to rapid. Steepness and chert content are the major limitations. Capability unit VIIs–9; not placed in a landsite group or woodland suitability group.

Doniphan Series

The Doniphan series consists of deep, gently sloping to steep, well-drained soils on the tops of ridges and on side slopes. These soils formed in material weathered from cherty dolomite or cherty limestone.

In a representative profile the surface layer is brown cherty silt loam about 4 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper 7 inches is mainly yellowish-red, firm silty clay that has reddish-yellow mottles; the next 17 inches is red clay that has reddish-yellow mottles; and the lower 32 inches is variegated red, strong-brown, and brownish-yellow clay.

Permeability is moderate. Available water capacity is moderate. Natural fertility is low.

Most areas of these soils are forested. Some areas have been cleared and are used for hay and pasture.

Representative profile of Doniphan cherty silt loam, 2 to 8 percent slopes, SW¼NW¼ sec. 22, T. 23 N., R. 1 W.:

A1—0 to 4 inches, brown (10YR 4/3) cherty silt loam; moderate, fine, granular structure; friable; estimated 30 percent chert; many roots; medium acid; clear, wavy boundary.

B&A—4 to 6 inches, brown (10YR 5/3) and strong-brown (7.5YR 5/6) silt loam; moderate, very fine, subangular blocky structure; friable; estimated 10 percent chert; many roots; strongly acid; clear, wavy boundary.

B21t—6 to 11 inches, yellowish-red (5YR 5/6) silty clay that has common, medium, distinct, reddish-yellow (7.5YR 6/6) mottles; strong, fine, angular blocky structure; firm; estimated 5 percent chert; many roots; strongly acid; clear, smooth boundary.

B22t—11 to 20 inches, red (2.5YR 4/8) clay that has few, medium, distinct, reddish-yellow (7.5YR 6/6) mottles; strong, fine, angular blocky structure; very firm; faint patchy clay films on peds; estimated 5 percent chert; few roots; strongly acid; gradual, wavy boundary.

B24t—28 to 60 inches, variegated, red (10YR 4/8), strong-brown (7.5YR 5/6), and brownish-yellow (10YR 6/6) clay; strong, fine, angular blocky structure; very firm; faint patchy clay films on peds; estimated 25 percent chert, some of which is decomposed tripolitic chert; few roots; very strongly acid.

The A horizon is 4 to 12 inches thick. It ranges from very dark grayish brown to brown in color and from 20 to 50 percent in chert content. In some areas there is loess material mixed with the surface layer, and the surface layer is almost free of chert. Reaction is strongly acid to

medium acid. The B horizon is strong brown to yellowish red in the upper part, and it is red and has common patterns of mottles in the lower part. Chert content ranges from 0 to 15 percent. There is some decomposed tripolitic chert. Reaction is very strongly acid to strongly acid.

Doniphan soils are associated with Poynor, Macedonia, and Clarksville soils. They have a thinner A horizon than Poynor soils. They have a more cherty surface layer than Macedonia soils, and a redder subsoil that has slightly more clay. Doniphan soils have a more clayey and less cherty subsoil than Clarksville soils.

Doniphan cherty silt loam, 2 to 8 percent slopes (DoB).—This soil is on the tops of ridges. It has the profile described as representative for the series. Chert fragments cover 15 to 35 percent of the surface. In some areas large boulders are on the surface.

Included with this soil in mapping are a few areas of Clarksville, Poynor, and Macedonia soils. In the southern part of the survey area there are some areas of Rock land.

This soil is suited to timber production, to hay and pasture, and to wildlife habitat. Surface runoff is medium. Capability unit IVs–6; landsite group B; woodland suitability group 4o7.

Doniphan cherty silt loam, 8 to 14 percent slopes (DoD).—This soil is on side slopes. It has a profile similar to that described as representative for the series. Chert fragments cover 25 to 35 percent of the surface.

Included with this soil in mapping are a few areas of Clarksville and Poynor soils.

This soil is suited to timber production, to pasture, and to wildlife habitat. Surface runoff is medium. Chert on the surface is the major limitation. Capability unit VIs–6; landsite group B; woodland suitability group 4o7.

Doniphan cherty silt loam, 14 to 35 percent slopes (DoE).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has more chert on the surface and a thinner surface layer. Chert fragments cover 20 to 35 percent of the surface.

Included with this soil in mapping are areas of Poynor and Clarksville soils. These soils are common and make up as much as 40 percent of the acreage mapped as this Doniphan soil.

This soil is suited to timber production and to wildlife habitat. Surface runoff is medium to rapid. Steepness is the major limitation. Capability unit VIIs–6; landsite group B; woodland suitability group 4r9.

Macedonia Series

The Macedonia series consists of deep, gently sloping to moderately steep, well-drained soils. These soils are on the tops of broad ridges and on side slopes. They formed in loess and in the underlying material weathered from cherty dolomite.

In a representative profile the surface layer is very dark grayish-brown silt loam about 2 inches thick. The transitional layer is brown and yellowish-brown silt loam about 4 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper part of the subsoil is yellowish-brown, friable silt loam; the middle part is strong-brown, friable cherty silty clay and silty clay that has red and yellowish-red mottles; and the lower part is strong-brown, firm silty clay and cherty clay that is mottled with shades of red, gray, and brown.

Permeability is moderate. Available water capacity is moderate. Natural fertility is low.

Most areas of these soils are used for timber production and for hay and pasture. A few areas are used for row crops.

Representative profile of Macedonia silt loam, 2 to 8 percent slopes, 20 feet south of Forest Service Road No. 4823, SE¼NW¼ sec. 31, T. 25 N., R. 1 W.:

A1—0 to 2 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, medium, granular structure; very friable; estimated 2 percent chert; many roots; roots; strongly acid; abrupt, wavy boundary.

A&B—2 to 6 inches, brown (10YR 5/3) and yellowish-brown (10YR 5/4) silt loam; moderate, medium, granular structure; very friable; estimated 2 percent chert; many roots; very strongly acid; clear, wavy boundary.

B1—6 to 14 inches, yellowish-brown (10YR 5/6) silt loam; moderate, medium, subangular blocky structure; friable; estimated 6 percent chert; many roots; strongly acid; clear, wavy boundary.

B21t—14 to 20 inches, strong-brown (7.5YR 5/6) cherty heavy silty clay; moderate, medium, subangular blocky structure; friable; patchy clay films on peds; estimated 20 percent chert; common roots; strongly acid; clear, wavy boundary.

B22t—20 to 36 inches, strong-brown (7.5YR 5/6) silty clay that has many, medium, distinct, red (2.5YR 4/6) mottles; strong, fine and very fine, angular blocky structure; friable; distinct, patchy, continuous clay films on peds; estimated 5 percent chert; common roots; very strongly acid; gradual, wavy boundary.

B23t—36 to 48 inches, strong-brown (7.5YR 5/6) silty clay that has many, medium, distinct, red (2.5YR 4/6) and gray (10YR 6/1) mottles; moderate, medium, subangular blocky structure breaking to strong, fine, angular structure; firm; distinct, patchy, yellowish-red (5YR 5/6) clay films on peds; estimated 3 percent chert; few roots; extremely acid; gradual, wavy boundary.

B3t—48 to 66 inches, strong-brown (7.5YR 5/6) cherty clay that has many, medium, prominent, red (3.5YR 4/6), light-gray (10YR 6/1), and very pale brown (10YR 7/3) mottles; moderate, medium, subangular blocky structure breaking to strong, fine, angular blocky; very firm; prominent, continuous, yellowish-red (5YR 5/6) clay films on peds; estimated 40 percent chert; very strongly acid.

The A horizon is 2 to 12 inches thick. It ranges from very dark brown to brown in color and from 0 to 15 percent in chert content. Reaction is very strongly acid to medium acid. The B horizon is yellowish brown to yellowish red. It ranges from heavy silt loam to silty clay in the upper part and from silty clay to clay in the lower part. Individual horizons are as much as 45 percent chert. Reaction ranges from extremely acid to strongly acid.

Macedonia soils are associated with Captina and Clarksville soils. They do not have a fragipan, but Captina soils do. They have less chert than Clarksville soils.

Macedonia silt loam, 2 to 8 percent slopes (MaB).—This soil is on the tops of broad ridges. It has the profile described as representative of the series. Chert fragments cover 0 to 15 percent of the surface.

Included with this soil in mapping are a few areas of Clarksville and Captina soils. In the southern part of the survey area, areas of Doniphan soils are also included.

This soil is suited to timber production, to hay and pasture, to small grain, and to wildlife habitat. Surface runoff is medium. Capability unit IIe–4; landsite group B; woodland suitability group 4o7.

Macedonia silt loam, 8 to 14 percent slopes (MaD).—This soil is on side slopes. It has a profile similar to that

described as representative for the series, but it contains more chert in the surface layer. Chert fragments cover 5 to 25 percent of the surface.

Included with this soil in mapping are areas of Poynor, Clarksville, and Wilderness soils.

This soil is suited to timber production, to pasture, and to wildlife habitat. Capability unit IVe–4; landsite group B; woodland suitability group 4o7.

Midco Series

The Midco series consists of deep, cherty, nearly level or gently sloping, somewhat excessively drained soils. These soils formed in cherty alluvium on first bottoms in valleys of narrow streams.

In a representative profile the surface layer is dark-brown cherty loam about 8 inches thick. The upper part of the subsoil is strong-brown, friable cherty loam over cherty sandy loam, and the lower part is strong-brown cherty and gravelly sandy loam.

Permeability is moderately rapid to rapid. Available water capacity is very low. Natural fertility is low.

Most areas of these soils are forested or are in pasture.

Representative profile of Midco cherty loam, 1 to 4 percent slopes, NW¼NW¼ sec. 13, T. 26 N., R. 3 W.:

A—0 to 8 inches, dark-brown (10YR 3/3) cherty loam; weak, fine, granular structure; friable; estimated 35 percent gravel and chert; many roots; slightly acid; abrupt, wavy boundary.

B21—8 to 17 inches, strong-brown (7.5YR 5/6) cherty loam; structureless; friable; estimated 75 percent gravel; common roots; medium acid; gradual, wavy boundary.

B22—17 to 26 inches, strong-brown (7.5YR 5/6) cherty coarse sandy loam; structureless; friable, estimated 50 percent gravel and chert; common roots; medium acid; clear, wavy boundary.

B23—26 to 60 inches, strong-brown (7.5YR 5/6) cherty coarse sandy loam; structureless; friable; estimated 80 percent gravel and chert; very few roots; medium acid.

The solum ranges from 30 inches to more than 60 inches in thickness. The A horizon is dark brown to dark yellowish brown and is 20 to 80 percent chert. Texture is dominantly cherty loam but is cherty fine sandy loam in places. The B horizon is strong brown to yellowish brown in color and is 40 to 90 percent chert. Reaction is medium acid to slightly acid throughout the profile.

Midco soils are associated with Secesh soils. They contain more chert throughout the profile than Secesh soils.

Midco cherty loam, 1 to 4 percent slopes (MdB).—This soil is on first bottoms in valleys of narrow streams. It has the profile described as representative for the series. Most of the areas are linear, and the long axis is parallel to the drainageways.

Included with this soil in mapping are areas of Alluvial land, loamy, and Secesh soils.

This soil is suited to pasture and to wildlife habitat. Surface runoff is slow. Droughtiness, flooding, and chert content are the major limitations. Capability unit IIIs–1; landsite group E; woodland suitability group 5f9.

Newark Series

The Newark series consists of deep, nearly level, somewhat poorly drained soils. These soils formed in alluvium on first and second bottoms near drainageways.

In a representative profile the surface layer is dark grayish-brown silt loam about 4 inches thick. The subsurface layer is light brownish-gray silt loam that has faint, brown mottles and is about 7 inches thick. The subsoil reaches to a depth of more than 55 inches. The upper part of the subsoil is pale-brown and yellowish-brown, friable or firm silt loam that has brown mottles; the middle part is light brownish-gray, firm silt loam that has yellowish-brown and yellowish-red mottles; and the lower part is yellowish-brown and gray, firm silty clay loam that has brown mottles. The subsurface layer and the subsoil contain many iron and manganese concretions.

Permeability is moderate. Available water capacity is high. Natural fertility is medium.

Most areas of these soils are used for timber production. They provide food and cover for wildlife.

Representative profile of Newark silt loam, 0 to 2 percent slopes, NW¼NW¼ sec. 4, T. 24 N., R. 1 W.:

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

A2—4 to 11 inches, light brownish-gray (10YR 6/2) silt loam that has few, fine, faint, brown (10YR 5/3) mottles; weak, fine, subangular blocky structure; friable; many roots; 5 percent manganese concretions 2 millimeters in size; slightly acid; abrupt, smooth boundary.

B1—11 to 16 inches, pale-brown (10YR 6/3) silt loam that has common, medium, faint, dark yellowish-brown (10YR 3/4) mottles and few, fine, prominent, dark reddish-brown (5YR 3/4) mottles; weak, fine, subangular blocky structure; friable; common roots; 5 percent manganese concretions 2 millimeters in size; neutral; clear, wavy boundary.

B21—16 to 26 inches, yellowish-brown (10YR 5/6) heavy silt loam that has many, medium, distinct, very pale brown (10YR 7/3) mottles and few, fine, prominent, dark reddish-brown (5YR 3/4) mottles; weak, fine, subangular blocky structure; firm; few roots; 10 percent manganese concretions 6 millimeters in size; neutral; gradual, wavy boundary.

B22g—26 to 36 inches, light brownish-gray (2.5Y 6/2) heavy silt loam that has many, coarse, prominent, yellowish-brown (10YR 5/6) mottles and few, fine, prominent, yellowish-red (5YR 4/6) mottles; weak, fine, subangular blocky structure; firm; few roots; 5 percent manganese concretions 6 millimeters in size; neutral; gradual, wavy boundary.

B23—36 to 46 inches, yellowish-brown (10YR 5/6) and gray (10YR 5/1) light silty clay loam that has few, fine, faint, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; firm; few roots; 5 percent manganese concretions 6 millimeters in size; neutral; gradual, wavy boundary.

B3—46 to 55 inches, gray (10YR 5/1) light clay loam that has coarse, common, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; firm; few roots; 2 percent manganese concretions 10 millimeters in size; neutral.

The solum ranges from 40 inches to more than 60 inches in thickness. The Ap horizon is dark grayish brown to dark brown. In some areas the A horizon is loam. Brown, red, and gray mottles begin at a depth of 3 to 8 inches. The B horizon is 30 to 50 inches thick. Reaction is slightly acid to neutral throughout the profile.

Newark soils are associated with Ashton and Secesh soils. They are not so well drained as the Ashton or the Secesh soils.

Newark silt loam, 0 to 2 percent slopes (NeA).—This soil is on first and second bottoms along the major drainageways. It has the profile described as representative for the series. Areas of this soil are irregular in shape.

Included with this soil in mapping are a few small areas of Ashton and Secesh soils.

This soil is suited to most hardwoods, to crops, and to use as wildlife habitat. Surface runoff is slow. Seasonal wetness, imperfect drainage, and occasional flooding are the major limitations. Capability unit IIw–1; landsite group B; woodland suitability group 4w8.

Opequon Series

The Opequon series consists of shallow, rocky, moderately steep to very steep, well-drained soils. These soils are on slopes near major drainageways. They formed in residuum weathered from dolomitic limestone. Soil material and exposed bedrock form a landscape of steplike slopes.

In a representative profile the surface layer is dark-brown cherty silty clay loam about 5 inches thick. The subsoil is about 14 inches thick. The upper part of the subsoil is yellowish-red, firm clay, and the lower part is red and dark-red, very firm clay. Below this is sandy dolomitic limestone bedrock.

Permeability is moderately slow. Available water capacity is very low. Natural fertility is medium.

The limited capacity of these soils to support timber results in natural openings in the forest that permit the growth of plant communities. These communities provide food and cover for wildlife. They are also esthetically appealing.

Representative profile of Opequon rocky silty clay loam, 8 to 14 percent slopes, about 150 feet west of State Highway in NE¼NE¼ sec. 22, T. 27 N., R. 1 W.:

A1—0 to 5 inches, dark-brown (7.5YR 3/2) cherty silty clay loam; moderate, fine, subangular blocky structure; firm; estimated 20 percent chert; many roots; slightly acid; abrupt, smooth boundary.

B21t—5 to 9 inches, yellowish-red (5YR 4/6) clay; strong, medium, subangular blocky structure; firm; faint patchy clay films on peds; estimated 5 percent chert; many roots; slightly acid; clear, wavy boundary.

B22t—9 to 13 inches, red (2.5YR 4/6) clay; strong, medium, subangular blocky structure; very firm; faint patchy films on peds; estimated 15 percent chert; common roots; neutral; clear, wavy boundary.

B23t—13 to 19 inches, dark-red (2.5YR 3/6) clay; strong, medium, subangular blocky structure; very firm; faint, patchy clay films on peds; estimated 15 percent chert; common roots; neutral.

R—19 inches, sandy dolomitic limestone bedrock; effervesces weakly.

The thickness of the solum and the depth to bedrock range from 12 to 20 inches. Exposed bedrock covers as much as 25 percent of the surface. The A horizon ranges from dark brown to dark yellowish brown in color and is 10 to 25 percent chert. It is dominantly silty clay loam, but in places it is silt loam or loam. The B horizon is dark reddish brown to yellowish red. Texture is clay or silty clay. Reaction is neutral to slightly acid throughout the profile.

Opequon soils are associated with Clarksville, Coulstone, Doniphan, and Poynor soils. They are shallower to bedrock than Clarksville, Coulstone, Doniphan, and Poynor soils.

Opequon rocky silty clay loam, 8 to 14 percent slopes (OpD).—This soil is on ridges and side slopes. It has the profile described as representative for the series. Limestone outcrops and ledges make up as much as 15 percent of the areas. Stones cover 10 to 35 percent of the surface.

Included with this soil in mapping are a few areas of Rock land and a few areas of soils that are slightly deeper to bedrock.

This soil is suited to cedar trees and to wildlife habitat. Surface runoff is medium to rapid. The hazard of erosion is moderate. Steepness and shallowness of this soil are the major limitations. Capability unit VIIs–8; landsite group D; woodland suitability group 5d9.

Opequon rocky silty clay loam, 14 to 35 percent slopes (OpE).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has a higher chert content throughout the profile and a surface layer that is thinner because of erosion. Limestone outcrops and ledges make up as much as 25 percent of the areas. Stones cover 20 to 35 percent of the surface.

Included with this soil in mapping are a few small areas of Rock land and areas of soils that are slightly deeper to bedrock.

This soil is suited to cedar trees and to wildlife habitat. Surface runoff is medium to rapid. Steepness and shallowness are the major limitations. Capability unit VIIs–8; landsite group D; woodland suitability group 5d9.

Opequon rocky silty clay loam, 35 to 60 percent slopes (OpF).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has a higher chert content and a thinner surface layer.

Included with this soil in mapping are areas of Rock land and areas of soils that are slightly deeper to bedrock.

This soil is suited to cedar trees and to wildlife habitat. Surface runoff is medium to rapid. Steepness and shallowness are the major limitations. Capabiilty unit VIIs–8; landsite group D; woodland suitability group 5d9.

Poynor Series

The Poynor series consists of deep, well-drained soils. These soils are gently sloping on the tops of narrow ridges and moderately steep to very steep on side slopes in highly dissected areas. They formed in material weathered from cherty dolomite or cherty limestone.

In a representative profile the surface layer is brown cherty silt loam about 4 inches thick. The subsurface layer is yellowish-brown silt loam about 6 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper part of the subsoil is yellowish-red, firm cherty silty clay loam, and the lower part is red and brownish-yellow, very firm clay.

Permeability is moderate. Available water capacity is low to moderate. Natural fertility is low.

Most areas of these soils are forested. Some areas are used for hay and pasture.

Representative profile of Poynor cherty silt loam, 2 to 8 percent slopes, NE¼SE¼ sec. 5, T. 25 N., R. 1 E.:

A1—0 to 4 inches, brown (10YR 4/3) cherty silt loam; moderate, fine and very fine, granular structure; friable; estimated 25 percent chert; many roots; strongly acid; abrupt, smooth boundary.

A2—4 to 10 inches, yellowish-brown (10YR 5/4) silt loam; weak, very fine, granular structure; friable; estimated 10 percent chert; many roots; strongly acid; clear, wavy boundary.

B1—10 to 18 inches, yellowish-red (5YR 5/6) cherty light silty clay loam that has few, fine, faint, brown

(10YR 5/3) mottles; weak, fine, subangular structure; firm; estimated 40 percent chert; common roots; strongly acid; clear, wavy boundary.

B21t—18 to 28 inches, yellowish-red (5YR 4/8) cherty silty clay loam; moderate, very fine, subangular blocky structure; very firm; faint patchy clay films on peds; estimated 60 percent chert; few roots; strongly acid; clear, irregular boundary.

IIB22t—28 to 40 inches, red (2.5YR 4/6) clay that has common, fine, distinct, brownish-yellow (10YR 6/6) mottles; strong, fine, angular blocky structure; very firm; faint patchy clay films on peds; few roots; medium acid; clear, wavy boundary.

IIB23t—40 to 60 inches, variegated, red (2.5YR 4/6) and brownish-yellow (10YR 6/6) clay; moderate, fine, angular blocky structure; very firm; faint patchy clay films on peds; few roots; medium acid.

The A horizon ranges from very dark grayish brown to yellowish brown in color and from 20 to 50 percent in chert content. Reaction ranges from very strongly acid to slightly acid. The upper part of the B horizon is strong brown to yellowish red and 35 to 80 percent chert. Texture is light silty clay loam to silty clay. The lower part of the B horizon is yellowish red to red and is mottled in some places. It is 0 to 20 percent chert. Reaction in the B horizon ranges from very strongly acid to medium acid.

Poynor soils are associated with Doniphan, Clarksville, and Coulstone soils. They have a thicker surface layer than Doniphan soils. They have a more clayey subsoil than Clarksville soils. Poynor soils are less sandy than Coulstone soils.

Poynor cherty silt loam, 2 to 8 percent slopes (PyB).—This soil is on the tops of narrow ridges. It has the profile described as representative for the series. Chert fragments cover from 15 to 35 percent of the surface.

Included with this soil in mapping are small areas of Clarksville, Coulstone, Wilderness, and Doniphan soils. In the southern part of the survey area are some areas of Rock land.

This soil is suited to timber production and to limited use for hay and pasture. Surface runoff is medium Droughtiness and high chert content are the major limitations. Capability unit IVs–6; landsite group B; woodland suitability group 4f1.

Poynor cherty silt loam, 8 to 14 percent slopes (PyD).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has a surface layer that is thinner because of erosion. Chert fragments cover from 25 to 35 percent of the surface.

Included with this soil in mapping are a few areas of Clarksville and Coulstone soils. Also included are a few areas of soils that are shallow to bedrock.

This soil is suited to timber production and to limited use for pasture. Surface runoff is medium. Droughtiness and chert in the surface layer and on the surface are the major limitations. Capability unit VIs–6; landsite groups B and C; woodland suitability groups 4f1 and 5f9.

Poynor cherty silt loam, 14 to 35 percent slopes (PyE).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has more chert on the surface and a thinner surface layer. Chert fragments cover from 25 to 50 percent of the surface.

Included with this soil in mapping are a few areas of Clarksville and Coulstone soils and a few areas of soils that are shallow to bedrock.

This soil is suited to timber production. Surface runoff is medium to rapid. Steepness and chert content are the major limitations. Capability unit VIIs–6; landsite groups B and C; woodland suitability groups 4f9 and 5f9.

Poynor cherty silt loam, 35 to 60 percent slopes (PyF).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has more chert on the surface and a thinner surface layer. Chert fragments cover as much as 50 percent of the surface. In places large boulders are on the surface.

Included with this soil in mapping are a few areas of Clarksville and Coulstone soils and a few areas of soils that are shallow to bedrock.

This soil is suited to timber production. Surface runoff is medium to rapid. Steepness and chert content are the major limitations. Capability unit VIIs–6; landsite groups B and C; woodland suitability groups 4f9 and 5f9.

Rock Land

Rock land consists of areas where ledges and bedrock outcrops make up more than 25 percent of the surface. These areas are on moderately steep to very steep side slopes near drainageways in highly dissected areas.

The soil material between the dolomitic ledges and outcrops has a surface layer of very dark grayish-brown silty clay loam. The soil material is generally less than 15 inches deep. In places, however, it is as deep as 24 inches. Where the depth of the soil is more than 10 inches, the subsoil is dark yellowish-brown silty clay.

The water intake rate between the rocks and the fractures is rapid. Internal drainage is rapid. Available water capacity is very low. Natural fertility is medium.

Areas of this land type are generally similar to glades; much of the acreage is open or has a thin cover of plants. This feature results in natural openings in the forest that permit the growth of plant communities. These communities provide food and cover for wildlife. Areas of Rock land have high esthetic value (fig. 7).

Rock land, 8 to 14 percent slopes (RoD).—This land type is on side slopes. Ledges and bedrock make up 25 to 40 percent of the surface. The soil material and exposed bedrock form a landscape of steplike slopes.

Included with this land type in mapping are a few areas of Opequon soils and a few areas of soils that are slightly deeper to bedrock.

Most areas of Rock land are open or have a thin cover of redcedar, post oak, blackjack oak, and native grasses. This land type has low capacity for the production of marketable hardwoods and pine. It has fair capacity for the production of redcedar where the soil material is deep enough to support vegetation.

This land type is suited to use for water yield to springs and streams and to esthetic purposes. Surface runoff is rapid. Capability unit VIIs–10; landsite group F; woodland suitability group 5x0.

Rock land, 14 to 35 percent slopes (RoE).—This land type is on side slopes. Ledges and bedrock make up 35 to 50 percent of the surface. The vertical exposures of bedrock form a landscape of steep steps.

Included with this land type in mapping are a few small areas of Opequon soils.

Most areas of Rock land are open or have a thin cover of cedar, small oak, and native grasses.

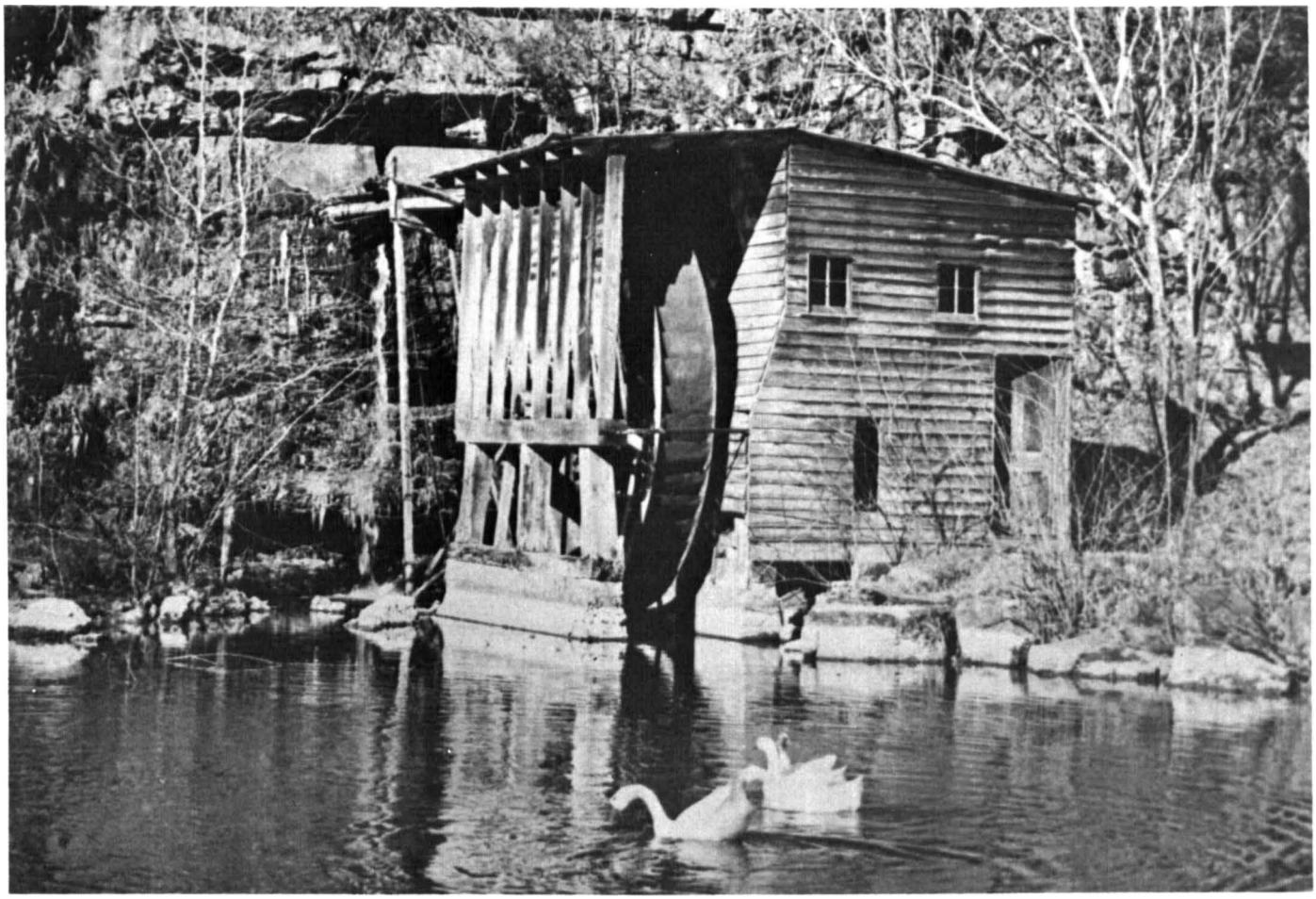

Figure 7.—**Falling Springs, near Winona, in an area of Rock land.**

This land type is suited to use for water yield to springs and streams and to esthetic purposes. Surface runoff is very rapid. Capability unit VIIs–10; landsite group F; woodland suitability group 5x0.

Rock land, 35 to 60 percent slopes (RoF).—This land type is on side slopes. Exposed bedrock makes up 35 to 75 percent of the surface. The vertical exposures of bedrock range from 3 feet to more than 25 feet in height and form a landscape of steep steps.

Included with this land type in mapping are a few small areas of Opequon soils.

Most areas of Rock land are open or have a thin cover of cedar, small oak, and native grass.

These areas are suited to use for water yield to springs and streams and to esthetic purposes. Capability unit VIIs–10; landsite group F; woodland suitability group 5x0.

Secesh Series

The Secesh series consists of deep, gently sloping; well-drained soils. These soils formed in alluvium on low stream terraces near drainageways.

In a representative profile the surface layer is dark-brown loam about 8 inches thick. The subsoil reaches to a depth of more than 60 inches. The upper 19 inches of the subsoil is strong-brown, friable loam, silty clay loam, and cherty silty clay loam. The lower part is yellowish-red and strong-brown cherty sandy clay loam.

Permeability is moderate. Available water capacity is moderate. Natural fertility is medium.

Most areas of these soils are used for timber production and for hay and pasture. Some areas are used for recreational facilities.

Representative profile of Secesh loam, 1 to 4 percent slopes, NE¼NW¼ sec. 4, T. 25 N., R. 2 W.:

Ap—0 to 8 inches, dark-brown (10YR 3/3) loam; weak, fine, granular structure; very friable; estimated 5 percent chert; many roots; slightly acid; abrupt, smooth boundary.

B1—8 to 11 inches, strong-brown (7.5YR 5/6) and dark-brown (10YR 3/3) loam; weak, fine, granular structure; very friable; estimated 5 percent chert; many roots; medium acid; clear, wavy boundary.

B21t—11 to 19 inches, strong-brown (7.5YR 5/6) silty clay loam; moderate, medium, subangular blocky structure; friable; estimated 10 percent chert; common roots; strongly acid; gradual, wavy boundary.

B22t—19 to 27 inches, strong-brown (7.5YR 5/6) cherty light silty clay loam; moderate, medium, subangular blocky structure; friable; faint patchy clay films on peds; estimated 25 percent chert; common roots; strongly acid; gradual, wavy boundary.

IIB23t—27 to 39 inches, yellowish-red (5YR 4/8) cherty light sandy clay; moderate, medium, subangular blocky structure; friable; distinct patchy clay films on peds; estimated 45 percent chert; few roots; strongly acid; gradual, wavy boundary.

IIB31t—39 to 51 inches, yellowish-red (5YR 5/8) cherty clay loam; weak, fine, subangular blocky structure; friable; distinct patchy clay films on peds; estimated 75 percent chert; strongly acid; clear, wavy boundary.

IIB32t—51 to 65 inches, strong-brown (7.5YR 5/8) cherty sandy clay loam with common, medium, distinct, yellowish-red (5YR 4/8) mottles; weak, fine, subangular blocky structure; very friable; distinct patchy clay films on peds; estimated 65 percent chert; very strongly acid.

The solum ranges from 30 inches to more than 60 inches. The Ap horizon ranges from very dark grayish brown to brown in color and is 0 to 15 percent chert. The B1 horizon is dark yellowish brown or strong brown. Texture is loam, light sandy clay loam, or light silty clay loam. The B2t horizon is strong brown or yellowish red. Texture is sandy clay loam or light sandy clay. In the upper part of the B horizon chert content ranges from 10 to 50 percent; in the lower part it ranges from 35 to 80 percent. Reaction is medium acid to very strongly acid throughout the profile.

Secesh soils are associated with Ashton and Midco soils. They contain more chert than Ashton soils but are less cherty than Midco soils.

Secesh loam, 1 to 4 percent slopes (SeB).—This soil is on terraces along the major drainageways (fig. 8). Most areas are linear, and the long axis is parallel to the drainageways.

Included with this soil in mapping are a few small areas of Ashton and Midco soils.

This soil is suited to timber production, to hay and pasture, and to wildlife habitat. Some areas are also used for recreational facilities. Surface runoff is slow. Droughtiness and occasional flooding along the Current and Eleven Point Rivers are the major limitations. Capability unit IIs–1; landsite group B; woodland suitability group 4f7.

Viraton Series

The Viraton series consists of deep, gently sloping, moderately well drained soils that have a fragipan. These soils formed in colluvium on toe slopes at the foot of slopes and ridge ends.

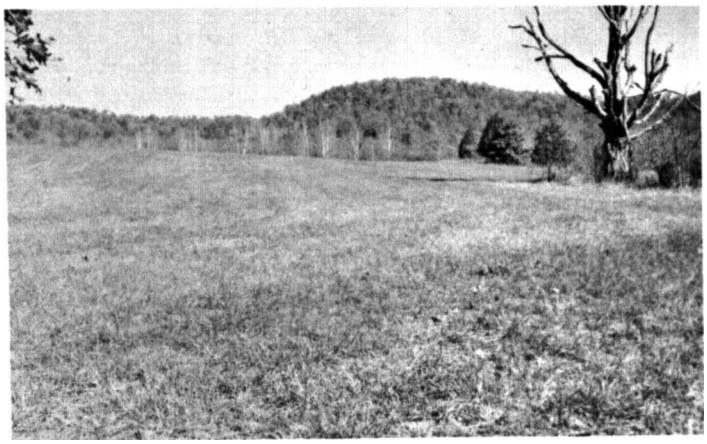

Figure 8.—Area of Secesh loam used for hay.

In a representative profile the surface layer is brown silt loam about 4 inches thick. The upper 11 inches of the subsoil is brown to strong-brown, friable to firm silty clay loam; the next 5 inches is strong-brown, firm cherty silty clay loam that has brown mottles; and below this there is a fragipan that reaches to a depth of more than 60 inches. The upper part of the fragipan is strong-brown and yellowish-red, firm cherty silty clay loam that has brown and gray mottles, and the lower part is yellowish-red, reddish-brown, and red, firm silty clay loam that has gray, brown, and yellow mottles.

Permeability is moderate above the fragipan and slow in the fragipan. Available water capacity is moderate. Natural fertility is medium.

Most areas are used for timber production. A few areas are used for pasture and hay.

Representative profile of Viraton silt loam, 2 to 8 percent slopes, SW¼NE¼ sec. 34, T. 26 N., R. 2 W.:

Ap—0 to 4 inches, brown (10YR 4/3) silt loam; weak, fine, granular structure; friable; estimated 2 percent chert; many roots; slightly acid; abrupt, wavy boundary.

B1—4 to 10 inches, brown (7.5YR 4/4) silty clay loam; weak, fine, subangular blocky structure; friable; estimated 2 percent chert; many roots; medium acid; clear, wavy boundary.

B21—10 to 15 inches, strong-brown (7.5YR 5/6) silty clay loam; weak, fine, subangular blocky structure; firm; estimated 2 percent chert; many roots; medium acid; clear, wavy boundary.

B22t—15 to 20 inches, strong-brown (7.5YR 5/6) cherty silty clay loam that has few, fine, distinct, grayish-brown (10YR 5/2) and dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; firm; faint patchy clay films on peds; estimated 25 percent chert; common roots; medium acid; clear, wavy boundary.

IIB'x1—20 to 29 inches, strong-brown (7.5YR 5/6) cherty silty clay loam that has many, medium, distinct, reddish-brown (5YR 4/4) and grayish-brown (10YR 5/2) mottles; moderate, very thick, platy structure breaking to moderate, medium, subangular blocky structure; firm; faint patchy clay films on peds; estimated 20 percent chert; few roots; strongly acid; clear, wavy boundary.

IIB'x2—29 to 34 inches, yellowish-red (5YR 4/6) cherty silty clay loam that has many, medium, distinct, light brownish-gray (10YR 6/2) and yellowish-brown (10YR 5/6) mottles; weak, thick, platy structure breaking to moderate, medium, subangular blocky; firm; distinct broken clay films on peds; estimated 20 percent chert; few roots; strongly acid; gradual, wavy boundary.

IIB'x3—34 to 52 inches, yellowish-red (5YR 4/6) and reddish-brown (5YR 4/4) silty clay loam that has many, medium, distinct, light brownish-gray (10YR 6/2) and yellowish-brown (10YR 5/6) mottles; moderate, fine, angular blocky structure; firm; distinct broken clay films on peds; estimated 5 percent chert; few roots; gray (2.5Y 5/0 and 6/0), vertical clay flows in old root channels; strongly acid; gradual, wavy boundary.

IIB'x4—52 to 60 inches, red (2.5YR 4/6) and yellowish-red (5YR 5/6) silty clay loam that has many, medium, distinct, light brownish-gray (10YR 6/2) and yellow (10YR 7/8) mottles; moderate, fine, angular blocky structure; firm; distinct broken clay films on peds; estimated 5 percent chert; gray (2.5Y 5/0 and 6/0), vertical clay flows in old root channels; strongly acid.

The solum ranges from 40 inches to more than 70 inches in thickness. The Ap horizon ranges from dark grayish brown to dark yellowish brown in color and is 0 to 15 percent chert. The B horizon is 12 to 26 inches thick and is brown, strong

brown, or yellowish brown. It is 0 to 25 percent chert. Texture is heavy silt loam to silty clay loam. Depth to the fragipan is 15 to 30 inches. The upper part of the fragipan is yellowish brown to strong brown, and the lower part is strong brown to red. Texture is silt loam to silty clay loam. Chert content ranges from 5 to 50 percent. Reaction ranges from strongly acid to slightly acid throughout the profile.

Viraton soils are associated with Clarksville, Coulstone, and Poynor soils. They have less chert throughout the profile than Clarksville, Coulstone, and Poynor soils.

Viraton silt loam, 2 to 8 percent slopes (VcB).—This soil is in long and narrow or irregularly shaped areas of colluvium at the foot of steep slopes and ridge ends. It has the profile described as representative for the series.

Included with this soil in mapping are a few areas of soils where the surface layer is more cherty than is typical of this Viraton soil. Also included are a few areas of soils that have a loam surface layer.

This soil is well suited to timber production, to pasture and hay, and to wildlife habitat. Surface runoff is medium. Capability unit IIe–5; landsite group A; woodland suitability group 3o7.

Wilderness Series

The Wilderness series consists of deep, moderately well drained soils that have a fragipan. These soils are gently sloping on the tops of ridges and moderately steep on upper side slopes. They formed in residuum mixed with loess.

In a representative profile the surface layer is brown cherty silt loam about 6 inches thick. The upper 11 inches of the subsoil is strong-brown, friable cherty silty clay loam. Below this is the fragipan. The upper part of the fragipan is pale-brown, cherty silt loam that is about 10 inches thick and has faint, brownish-yellow mottles; the lower part is strong-brown, cherty silty clay loam that is about 11 inches thick and has pale-brown mottles. Below the fragipan is yellowish-red and red, firm cherty silty clay that reaches to a depth of more than 60 inches.

Permeability is moderate in the upper layers and slow in the fragipan. Available water capacity is low. Natural fertility is very low.

Most areas of these soils are used for timber production and for pasture and hay.

Representative profile of Wilderness cherty silt loam, 2 to 8 percent slopes, SE¼SW¼ sec. 15, T. 26 N., R. 3 W.:

Ap—0 to 6 inches, brown (10YR 4/3) cherty silt loam; weak, very fine, subangular blocky structure; friable; estimated 20 percent chert; many roots; medium acid; abrupt, smooth boundary.

B2t—6 to 17 inches, strong-brown (7.5YR 5/6) cherty silty clay loam; weak, fine, subangular blocky structure; friable; estimated 55 percent chert; common roots; medium acid; gradual, wavy boundary.

IIAx—17 to 27 inches, pale-brown (10YR 6/3) cherty silt loam that has common, medium, faint, brownish-yellow (10YR 6/6) mottles; weak, fine, subangular blocky structure; chert controlled; estimated 80 percent chert; very strongly acid; gradual, wavy boundary.

IIBx—27 to 38 inches, strong-brown (7.5YR 5/6) cherty silty clay loam that has common, fine, distinct, pale-brown (10YR 6/3) mottles; weak, fine, subangular blocky structure; chert controlled; estimated 80 percent chert; very strongly acid; gradual, wavy boundary.

IIB2tb—38 to 60 inches, yellowish-red (5YR 5/6) and red (2.5YR 4/8) cherty silty clay; moderate, fine, subangular blocky structure; firm; estimated 80 percent chert; very strongly acid.

The A horizon ranges from dark grayish brown to brown in color and is 15 to 50 percent chert. The B horizon ranges from yellowish brown to yellowish red in color and is 35 to 70 percent chert. Depth to the fragipan is 15 to 22 inches. The fragipan ranges from 12 to 26 inches in thickness. It is pale brown to strong brown and has red, brown, and gray mottles. Chert content ranges from 40 to 85 percent. Reaction ranges from very strongly acid to medium acid throughout the profile.

Wilderness soils are associated with Captina and Clarksville soils. They are more cherty than Captina soils. They have a fragipan, which Clarksville soils lack.

Wilderness cherty silt loam, 2 to 8 percent slopes (WdB).—This soil is on the tops of ridges. It has the profile described as representative for the series. Chert fragments cover from 15 to 35 percent of the surface.

Included with this soil in mapping are a few areas of Clarksville and Captina soils.

This soil is suited to timber production, to pasture, and to wildlife habitat. Surface runoff is medium. The fragipan, which limits rooting depth, is the major limitation. Capability unit IVs–9; landsite group C; woodland suitability group 5f8.

Wilderness cherty silt loam, 8 to 14 percent slopes (WdD).—This soil is on side slopes. It has a profile similar to that described as representative for the series, but it has more chert in the surface layer.

Included with this soil in mapping are a few areas of Clarksville and Coulstone soils.

This soil is suited to timber production. Surface runoff is medium. Droughtiness, steepness, and the fragipan are the major limitations. Capability unit VIs–9; landsite group C; woodland suitability group 5f8.

Use and Management of the Soils

This section explains the use and mangement of the soils of Mark Twain National Forest Area for crops and pasture, timber production, wildlife habitat, and recreational activity. It also discusses engineering uses of the soils.

Management of the Soils for Crops and Pasture [2]

This subsection first explains the system of capability classification used by the Soil Conservation Service, and then discusses, by capability unit, the use and management of the soils in the survey area. A table showing the predicted yields of the principal groups under two levels of management is included.

About 10 percent of the Mark Twain National Forest Area is in crops and pasture. The principal plants grown for pasture and hay are tall fescue, orchardgrass, lespedeza, Ladino clover, red clover, alfalfa, redtop, timothy, sudangrass, sudex, milo, and millet. The row crops grown are corn and grain sorghum. A few areas are in wheat or oats.

[2] By Lewis H. Graves, Jr., soil scientist, Soil Conservation Service.

Most soils in the survey area have a low or moderate content of phosphate, potash, nitrogen, and calcium. Most are also low in organic-matter content.

The main needs in managing these soils for cultivation are conservation of moisture, control of erosion, prevention of overflow, maintenance or improvement of organic-matter content and fertility, and maintenance of good soil tilth. Contour farming, minimum tillage, the use of cover crops, green-manure crops, barnyard manure, and crop residue help to conserve moisture, to control erosion, and to maintain good tilth. Other management practices that can be used to control erosion are diversion ditches, terraces and terrace outlets, and fertility improvement and maintenance programs. Among the measures that help to maintain fertility are the application of chemical fertilizer, green manure, and barnyard manure, as well as the inclusion of cover crops, grasses, and legumes in the cropping system. To assure that the chert content does not interfere with tillage, it is necessary to remove stones and chert from the surface of many of the soils.

Capability grouping

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

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

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

Capability Classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife.

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.

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

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or to esthetic purposes. (None in the survey area)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, but not in the survey area, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or IIIe–5. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in the Mark Twain National Forest Area are described and suggestions for the use and management of the soils are given.

The soils in the survey area were assigned to capability units under a statewide system. Not all of the capability units in the State are represented in the survey area. Consequently, the numbering of the units is not consecutive.

CAPABILITY UNIT I–1

The only soil in this unit is Ashton silt loam, 1 to 4 percent slopes. This deep, well-drained soil is on first and second bottoms. It has a surface layer of silt loam and a subsoil of heavy silt loam.

Permeability is moderate. Available water capacity is high. Natural fertility is moderately high. Areas of this soil that are along major streams are subject to seasonal flooding.

This soil is well suited to all crops commonly grown in the area.

CAPABILITY UNIT IIe–1

The only soil in this unit is Claiborne silt loam, 2 to 8 percent slopes. This deep, well-drained soil is in either long and narrow or irregularly shaped areas of colluvium near drainageways on bottom lands. It has a surface layer of silt loam and a subsoil of silty clay loam.

Permeability is moderate. Available water capacity is high. Natural fertility is medium. Reaction is very strongly acid or strongly acid. Organic-matter content is low. The hazard of erosion is the major limitation to the use of this soil.

This soil is well suited to all the crops commonly grown in the survey area. The areas of this soil are small, and most of those that are cleared are in pasture or hay.

CAPABILITY UNIT IIe–4

The only soil in this unit is Macedonia silt loam, 2 to 8 percent slopes. This deep, well-drained soil is on broad ridges. It has a surface layer of silt loam and a subsoil that grades from silty clay loam in the upper part to silty clay or clay in the lower part.

Permeability is moderate. Available water capacity is moderate. Natural fertility is medium. Reaction is strongly acid or very strongly acid. Organic-matter content is low. There is a hazard of erosion if this slightly droughty soil is not managed properly.

This soil is suited to all the crops commonly grown in the area, such as pasture, hay, and small grain.

CAPABILITY UNIT IIe–5

Soils of the Captina and Viraton series are in this unit. These gently sloping, moderately well drained soils are on ridges and low slopes. They have a surface layer of silt loam, a subsoil of silty clay loam, and a cherty fragipan. Depth to the fragipan ranges from 18 to 36 inches.

Permeability is moderate down to the fragipan, and then it is slow. Available water capacity is moderate to low. Natural fertility is low. Reaction is strongly acid or very strongly acid. Organic-matter content is low. The fragipan restricts the rooting zone and the downward movement of water, thus increasing the hazard of erosion. The hazard of erosion is the major limitation to the use of these slightly droughty soils.

Cleared areas of these soils are well suited to pasture, hay, and small grain. Row crops can be grown if erosion is controlled.

CAPABILITY UNIT IIw–1

The only soil in this unit is Newark silt loam, 0 to 2 percent slopes. This deep, nearly level, somewhat poorly drained soil is on bottom lands. It has a surface layer of silt loam and a subsoil of heavy silt loam that grades with depth to silty clay loam.

Permeability is moderate. Available water capacity is high. Natural fertility is medium. Organic-matter content is very low. This soil is subject to occasional flooding, and wetness is a moderate limitation to its use.

This soil is suited to corn, soybeans, milo, and wheat, and to tall fescue and orchardgrass. It is well suited to some legumes, such as lespedeza and Ladino clover. It is poorly suited to alfalfa.

CAPABILITY UNIT IIs–1

The only soil in this unit is Secesh loam, 1 to 4 percent slopes. This deep, well-drained soil is on first and second bottoms. It has a surface layer of loam and a subsoil of light sandy clay loam.

Permeability is moderate. Available water capacity is moderate. Natural fertility is medium. Occasional flooding is a slight hazard along major streams. Droughtiness is the major limitation.

This soil is suited to all crops commonly grown in the survey area. Most areas of the soil are used for pasture or hay. Corn, soybeans, wheat, and milo are also grown to some extent.

CAPABILITY UNIT IIIe–5

The only soil in this unit is Captina silt loam, moderately shallow, 8 to 14 percent slopes. This moderately well drained soil is on low slopes and on sides of ridges. It has a surface layer of silt loam, a subsoil of silty clay loam, and a cherty fragipan.

Permeability is moderate down to the fragipan, and then it is slow. Available water capacity is moderate. Natural fertility is low. Reaction is strongly acid or very strongly acid. Organic-matter content is low. The fragipan restricts the rooting zone and the downward movement of water and thus increases the hazard of erosion. The hazard of erosion is the major limitation to the use of this slightly droughty soil.

Cleared areas of this soil are well suited to pasture and hay and to small grain. Row crops can be grown if erosion is controlled.

CAPABILITY UNIT IIIs–1

The only soil in this unit is Midco cherty loam, 1 to 4 percent slopes. This deep, somewhat excessively drained soil is on bottom lands. It has a surface layer of cherty loam and a subsoil of cherty loam and cherty sandy loam.

Permeability is moderately rapid to rapid. Available water capacity is very low. Natural fertility is low. Reaction ranges from slightly acid through very strongly acid. Chert content limits cultivation. The soil is subject to flooding in most places. Droughtiness is the major limitation.

This soil is suited to pasture, hay, and small grain. It is too droughty for row crops.

CAPABILITY UNIT IVe–1

The only soil in this unit is Claiborne silt loam, 8 to 14 percent slopes. This deep, well-drained soil is in low positions on the landscape. It has a surface layer of silt loam and a subsoil of silty clay loam.

Permeability is moderate. Available water capacity is high. Natural fertility is medium. Reaction is very strongly acid or strongly acid. Organic-matter content is low. The hazard of erosion is the major limitation.

This soil is too erodible to use intensively for crops, although it is well suited to all the crops commonly grown in the survey area. Areas of this soil are small, and most of those cleared are in permanent pasture.

CAPABILITY UNIT IVe–4

The only soil in this unit is Macedonia silt loam, 8 to 14 percent slopes. This deep, well-drained soil is on the sides of broad ridges. It has a surface layer of silt loam. The upper part of the subsoil is silty clay loam, and the lower part is silty clay or clay.

Permeability is moderate. Available water capacity is moderate. Natural fertility is medium. Reaction is very strongly acid. Organic-matter content is low. The hazard of erosion is a limitation if not controlled.

This soil is well suited to all the crops commonly grown in the survey area. It is suited to pasture and hay. This soil is too erodible to be used intensively for crops.

CAPABILITY UNIT IVs–1

This unit consists of Alluvial land, loamy. This land type is gently sloping and consists of sandy alluvial materials underlain by silt, gravel, or coarse sand.

Permeability is mostly moderately rapid. Available water capacity is mostly low. Natural fertility is low. Reaction ranges from slightly acid to strongly acid. This land type is subject to flooding. Droughtiness is a limitation.

Alluvial land, loamy, is suited to pasture and hay and to timber production.

CAPABILITY UNIT IVs–6

Soils of the Doniphan and Poynor series are in this unit. These deep, well-drained, gently sloping soils are mainly on the tops of ridges. They have a surface layer of very cherty silt loam and a subsoil of clay or very cherty silty clay loam over clay.

Permability is moderate. Available water capacity is low to moderate. Natural fertility is medium or low. Reaction ranges from medium acid to very strongly acid. Organic-matter content is low. Chert content of the surface layer limits cultivation of these droughty soils.

These soils are suited to hay, pasture, and small grain. Drought-tolerant grasses and legumes should be used.

CAPABILITY UNIT IVs–9

Soils of the Clarksville, Coulstone, and Wilderness series are in this unit. These deep, cherty, gently sloping, somewhat excessively drained and moderately well drained soils are generally on the tops of narrow ridges. They have a surface layer of cherty fine sandy loam or cherty silt loam. The subsoil is cherty sandy clay loam, cherty silty clay loam, cherty silty clay, or cherty clay.

Permeability is moderate to rapid. Available water capacity is very low to low. Natural fertility is low. Reaction is strongly acid to very strongly acid. Chert content limits cultivation of these droughty soils. The cherty fragipan of the moderately well drained Wilderness soils is at a depth of 15 to 20 inches, and it restricts the rooting zone of plants. Permeability in the Wilderness soils is moderate down to the fragipan, and then it is slow.

These soils are suited to hay, pasture, and small grain. Drought-tolerant grases and legumes should be used.

CAPABILITY UNIT Ve–15

This unit consists only of Alluvial land, mixed. This land type is a combination of riverwash, stratified sand and gravel, and severely channeled alluvial land along major streams.

Areas of this unit are subject to frequent flooding.

This soil is suited to a mixture of trees and permanent grass.

CAPABILITY UNIT VIs–6

Soils of the Doniphan and Poynor series are in this unit. These deep, well-drained, moderately steep soils are on side slopes. They have a surface layer of very cherty silty clay loam over clay.

Permeability is moderate. Available water capacity is low to moderate. Natural fertility is medium or low. Reaction ranges from medium acid to very strongly acid. Organic-matter content is low. Chert content and the mederately steep slopes restrict cultivation. In places large stones prevent cultivation. Droughtiness is the main limitation in the use of these soils.

These soils are suited to pasture, hay, and small grain. Drought-tolerant grasses and legumes should be used.

CAPABILITY UNIT VIs–9

Soils of the Clarksville, Coulstone, and Wilderness series are in this unit. Areas of Rock land are included with the Coulstone and Clarksville soils. These deep, somewhat excessively drained and moderately well drained, moderately steep soils are on side slopes. They have a surface layer of cherty fine sandy loam or cherty silt loam. The subsoil is cherty sandy clay loam, cherty silty clay loam, cherty silty clay, or cherty clay.

Permeability is slow to rapid. Available water capacity is very low or low. Natural fertility is low. Reaction is mostly strongly acid to very strongly acid. Chert content restricts cultivation. In places large boulders or rock outcrops prevent the use of machinery. The cherty fragipan of the moderately well drained Wilderness soils is at a depth of 15 to 22 inches, and it restricts the rooting zone of plants. Permeability in the Wilderness soils is moderate down to the fragipan, and then it is slow. In the areas of Rock land, permeability is variable, available water capacity is very low, natural fertility is medium, reaction is slightly acid or neutral, and drainage is variable.

These soils are suited to pasture, hay, and small grain. Drough-tolerant grasses and legumes should be used.

CAPABILITY UNIT VIIs–6

The steep Doniphan soils and the steep and very steep Poynor soils are in this unit. These deep, well-drained soils are on side slopes. They have a surface layer of very cherty silt loam and a subsoil of clay or very cherty silty clay loam over clay.

Permeability is low to moderate. Available water capacity is low to moderate. Natural fertility is low or medium. Reaction ranges from medium acid to very strongly acid. Organic-matter content is low. In places large stones and steep slopes prevent the use of machinery. These soils are droughty.

These soils are suited to timber or to permanent pasture. Drought-tolerant grasses should be used.

CAPABILITY UNIT VIIs–8

Soils of the Opequon series are in this unit. These shallow, well-drained, moderately steep to very steep soils are on side slopes. They have a surface layer of cherty silty clay loam and a subsoil of silty clay. There are numerous large stones, boulders, and outcrops or ledges of bedrock.

Permeability is moderately slow. Available water capacity is very low. Natural fertility is medium. Reaction is slightly acid or neutral. Organic-matter content is medium. In many places large stones, boulders, outcrops of bedrock, and steep slopes prevent the use of machinery. These soils are very droughty.

These soils are suited to timber or to permanent pasture. Drought-tolerant grasses should be used.

CAPABILITY UNIT VIIs-9

The soils in this unit are mostly of the Clarksville and Coulstone series. These dominantly deep, somewhat excessively drained, steep and very steep soils are on side slopes. There are areas of Rock land in places.

Permeability is mostly moderate to rapid. Available water capacity is very low or low. Natural fertility is low. Reaction is mostly strongly acid to very strongly acid. In places large boulders, rock outcrops, and steep slopes prevent the use of machinery. These soils are droughty. In the areas of Rock land, permeability is variable, natural fertility is medium, reaction is slightly acid or neutral, and drainage is variable.

These soils are suited to timber or to permanent pasture. Drought-tolerant grasses should be used.

CAPABILITY UNIT VIIs-10

This unit consists only of Rock land. Areas of this unit are moderately steep to very steep. The shallow soils between the rocks are variable. Large boulders and outcrops or ledges of sandstone or limestone cover more than 25 percent of the surface. Limestone flagstones cover the surface in some places.

Available water capacity is very low. The numerous rocks or ledges prevent the use of machinery.

Rock land is suited to native grasses or to cedar trees.

Predicted yields

The predicted average acre yields of the principal crops grown in the survey area are given in table 2 for each soil under two level of management. These estimates are based primarily on information obtained from experimental data, from farmers, and from others who are familiar with the soils and the crops of the area.

In columns A are listed those yields to be expected under ordinary management. Under this level of management, only minimum lime and fertilizer levels are maintained; crops are not always planted at the right time; a systematic program for controlling weeds, insects, and plant diseases is not followed; and pastures and meadows are commonly overgrazed or are not properly rotated.

Yields in columns B are those to be expected under improved management. Under this level of management, fertilizer and lime are applied according to soil tests; good cropping systems and erosion control practices are used; proper equipment is used at the right time to prepare the soils, plant the crops, control weeds, and harvest the crops; a systematic program for controlling insects and plant diseases is followed; and crop varieties that are well suited to the soils and to the type of farming operation are chosen.

The yields given in table 2 are based on the average rainfall in the area. They reflect the combined effects on the soils of slope, erosion, weather, and level of management. They are yields for nonirrigated soils. The hazard of flooding is not considered, because damage to crops is generally low on the soils of the bottom lands.

Management of the Soils for Timber

The first serious logging in the Ozarks began in the 1880's, and logging then continued until 1920. Sawmills at Grandin and West Eminence were rated the largest in the nation for several years. At present, a large part of the local economy is still supported by wood-using industries. There is a good market in the area for pine posts and for hardwood and pine sawtimber. Among the sawtimber products are oak flooring, pallet lumber, ties, and pine lumber. A ready market also exists for walnut, but this species is in limited quantity over much of the area. The market for hardwood cordwood is poor, and only about 5 percent of the hardwood that could be cut annually for cordwood is used by industry.

During the early period of logging, most of the virgin pine and oak in the area was cut. The burning and grazing that followed logging contributed to the deterioration of sites and hindered the regeneration of many desirable timber species. In the Ozarks, the composition of a stand of trees may be attributed more to management of young stands than to the quality of the site. If the merchantable pine in an oak-pine stand is removed, for example, it is replaced by various hardwoods. Also, after a fire the less desirable blackjack and post oak sprout prolifically. Continued burning apparently encourages the growth of these species over the more desirable oaks and pine. With these facts in mind, the selection of species to be grown for sawlogs should depend upon soil suitability and site characteristics and not on the species already growing on the site.

Forest types

The major forest types in the survey area are oak-hickory, oak-pine, and pine. Scarlet oak, black oak, and white oak are on the best sites (fig. 9). Blackjack and post oak are the dominant species on the less productive sites. Shortleaf pine, the only pine native to Missouri, occurs throughout the area.

Landsite groups

Timber management can be planned effectively if soils are grouped according to those characteristics that most affect the growth of trees. In this subsection, soils that have similar potential for growing trees have been placed in landsite groups. A landsite is an area of land having boundaries that are determined by soils, topographic position, aspects, and microclimate. Six landsites have been developed and are designated by a capital letter. The range of these groupings is from A, the most productive, to F, the least productive.

Table 3, on pages 26 and 27, evaluates most of the soils in the area according to woodland suitability group and landsite group. The soils within these groups are rated according to potential productivity, management hazards or limitations, and species suitable for planting. Alluvial land, loamy; Alluvial land, mixed; and the Coulstone-Clarksville-Rock land complex were not evaluated.

TABLE 2.—*Predicted average acre yields of the principal crops under two levels of management*

[Yields in columns A are those to be expected under ordinary management, and yields in columns B are those to be expected under improved management. Absence of a yield figure indicates that the soil is not suited to the crop]

Soil	Corn		Wheat		Hay						Pasture			
					Orchardgrass and clover		Tall fescue		Tall fescue and lespedeza		Tall fescue and lespedeza		Tall fescue	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*A.U.D.*[1]	*A.U.D.*[1]	*A.U.D.*[1]	*A.U.D.*[1]
Alluvial land, loamy							1. 0	1. 5	1. 25	1. 75	70	100	55	85
Alluvial land, mixed														
Ashton silt loam, 1 to 4 percent slopes	50	85	30	40	3. 0	4. 0	2. 5	3. 5	2. 75	3. 75	160	215	140	200
Captina silt loam, 2 to 8 percent slopes			25	35	2. 0	2. 75	1. 75	2. 5	2. 0	2. 75	115	160	100	145
Captina silt loam, moderately shallow, 2 to 8 percent slopes			25	35	2. 0	2. 75	1. 75	2. 5	2. 0	2. 75	115	160	100	140
Captina silt loam, moderately shallow, 8 to 14 percent slopes			20	30	1. 75	2. 5	1. 5	2. 25	1. 75	2. 5	100	145	85	130
Claiborne silt loam, 2 to 8 percent slopes	35	65	25	35	2. 0	2. 75	1. 75	2. 5	2. 0	2. 75	115	160	100	140
Claiborne silt loam, 8 to 14 percent slopes			20	30	1. 75	2. 5	1. 5	2. 25	1. 75	2. 5	100	145	85	130
Clarksville cherty silt loam, 2 to 8 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Clarksville cherty silt loam, 8 to 14 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Clarksville cherty silt loam, 14 to 35 percent slopes											70	110	55	110
Clarksville cherty silt loam, 35 to 60 percent slopes														
Coulstone cherty fine sandy loam, 2 to 8 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Coulstone cherty fine sandy loam, 8 to 14 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Coulstone cherty fine sandy loam, 14 to 35 percent slopes											70	110	55	100
Coulstone cherty fine sandy loam, 35 to 60 percent slopes														
Coulstone-Clarksville-Rock land complex, 8 to 14 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Coulstone-Clarksville-Rock land complex, 14 to 35 percent slopes											80	125	65	105
Coulstone-Clarksville-Rock land complex, 35 to 60 percent slopes														
Doniphan cherty silt loam, 2 to 8 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Doniphan cherty silt loam, 8 to 14 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Doniphan cherty silt loam, 14 to 35 percent slopes											65	95	55	85
Macedonia silt loam, 2 to 8 percent slopes			25	35	2. 0	2. 75	1. 75	2. 5	2. 0	2. 75	115	160	100	140
Macedonia silt loam, 8 to 14 percent slopes			20	30	1. 75	2. 5	1. 5	2. 25	1. 75	2. 5	115	160	85	130
Midco cherty loam, 1 to 4 percent slopes			20	30			1. 25	2. 0	1. 5	2. 25	85	130	70	110
Newark silt loam, 0 to 2 percent slopes	55	75	25	35			2. 75	3. 25	3. 0	3. 5	170	200	160	185
Opequon rocky silty clay loam, 8 to 14 percent slopes														
Opequon rocky silty clay loam, 14 to 35 percent slopes														
Opequon rocky silty clay loam, 35 to 60 percent slopes														
Poynor cherty silt loam, 2 to 8 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Poynor cherty silt loam, 8 to 14 percent slopes							1. 25	2. 0	1. 5	2. 25	85	130	70	110
Poynor cherty silt loam, 14 to 35 percent slopes											65	110	50	95
Poynor cherty silt loam, 35 to 60 percent slopes														
Rock land, 8 to 14 percent slopes														

See footnote at end of table.

TABLE 2.—*Predicted average acre yields of the principal crops under two levels of management*—Continued

Soil	Corn		Wheat		Hay						Pasture			
					Orchardgrass and clover		Tall fescue		Tall fescue and lespedeza		Tall fescue and lespedeza		Tall fescue	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*A.U.D.*[1]	*A.U.D.*[1]	*A.U.D.*[1]	*A.U.D.*[1]
Rock land, 14 to 35 percent slopes	----	----	----	----	------	------	------	------	------	------	-------	-------	-------	-------
Rock land, 35 to 60 percent slopes	----	----	----	----	------	------	------	------	------	------	-------	-------	-------	-------
Secesh loam, 1 to 4 percent slopes	50	70	28	38	2. 75	3. 75	2. 5	3. 5	2. 75	3. 75	155	210	140	200
Viraton silt loam, 2 to 8 percent slopes	----	----	25	35	2. 0	2. 75	1. 75	2. 5	2. 0	2. 75	110	155	100	145
Wilderness cherty silt loam, 2 to 8 percent slopes	----	----	15	20	------	------	1. 0	1. 5	1. 25	1. 75	70	100	55	85
Wilderness cherty silt loam, 8 to 14 percent slopes	----	----	15	20	------	------	1. 0	1. 5	1. 25	1. 75	70	100	55	85

[1] A.U.D. (animal-unit-day) is a term used to express the number of days one animal unit can graze 1 acre without injury to the pasture. An animal unit is one cow, one steer, one horse, five hogs, or seven sheep.

***Figure 9.*—Young stand of hardwoods on Clarksville cherty silt loam.**

Woodland suitability groups

The soils of the survey area have been placed in woodland suitability groups to assist in the management of the private land in the area.

Each woodland group is identified by a three-part symbol. The first part of the symbol is a number. It indicates relative potential productivity of the soils in the group: 1 means very high; 2 means high; 3 means moderately high; 4 means moderate; and 5 means low. These ratings are based on field determinations of the average site index, which is the average height of the dominant and codominant trees in a stand at 50 years of age.

The second part of the symbol is a small letter. It indicates an important soil property that imposes a hazard or limitation on the management of the soils for wood crops. A letter *x* shows that the main limitation of the soils is due to stones or rocks; *w* shows that the soils have restricted drainage, a high water table, or a hazard of overflow; *d* shows that the soils have restricted rooting depth and that there is a hazard of windthrow; *f* shows that the soils have limitations caused by coarse fragments in the profile; *r* shows that the soils have limitations caused by steepness or by slope; and *o* shows that the soils have no significant limitations.

The third part of the symbol is a number. It indicates the degree of hazard or limitation and the general suitability of the soils for certain kinds of trees.

The numeral *1* indicates soils that have few if any limitations and are suited to coniferous trees.

The numeral *2* indicates soils that have one or more moderate limitations and are suited to coniferous trees.

The numeral *3* indicates soils that have one or more severe limitations and are suited to coniferous trees.

The numeral *4* indicates soils that have few if any limitations and are suited to deciduous trees.

The numeral *5* indicates soils that have one or more moderate limitations and are suited to deciduous trees.

The numeral *6* indicates soils that have one or more severe limitations and are suited to deciduous trees.

The numeral *7* indicates soils that have few if any limitations and are suited to either coniferous or deciduous trees.

The numeral *8* indicates soils that have one or more moderate limitations and are suited to either coniferous or deciduous trees.

The numeral *9* indicates soils that have one or more severe limitations and are suited to either coniferous or deciduous trees.

The numeral *0* indicates soils that are not suitable for the production of commercial timber.

The potential productivity of the woodland suitability groups and the landsite groups, based on the hazards or limitations of management of the soils and including the influence of aspect (fig. 10), is expressed in terms of site index and estimated average annual growth per acre. The average annual growth per acre is given in board feet for a managed, well-stocked stand of trees.

Aspect is north and east if the slope is more than 8 percent and the azimuth of the direction of the slope is between 330° and 120°. It is south and west if the slope is more than 8 percent and the azimuth of the direction of the slope is between 120° and 330°. Aspect or direction of slope influences factors of soil productivity. North- and east-facing slopes are generally moist and cool, and south- and west-facing slopes are warm and dry. Shortleaf pine can tolerate a drier site than can most hardwoods. Sycamore, maple, ash, and elm are on the moist or wet bottom lands. Black walnut grows best on deep, well-drained bottom-land soils.

Limitations shown in table 3 are expressed in the relative terms of slight, moderate, and severe. These terms express the degree of the hazards and limitations explained in the following paragraphs.

Erosion hazard is rated according to the risk of erosion on forest land where normal practices are used in managing and harvesting trees. A rating of *slight* indicates soil loss is not an important concern; *moderate* indicates that some attention is required to check soil loss; and *severe* indicates that intensive treatments or special equipment and methods of operation are required to minimize soil erosion. The potential erosion hazard is based on slope, soil depth, and erodibility.

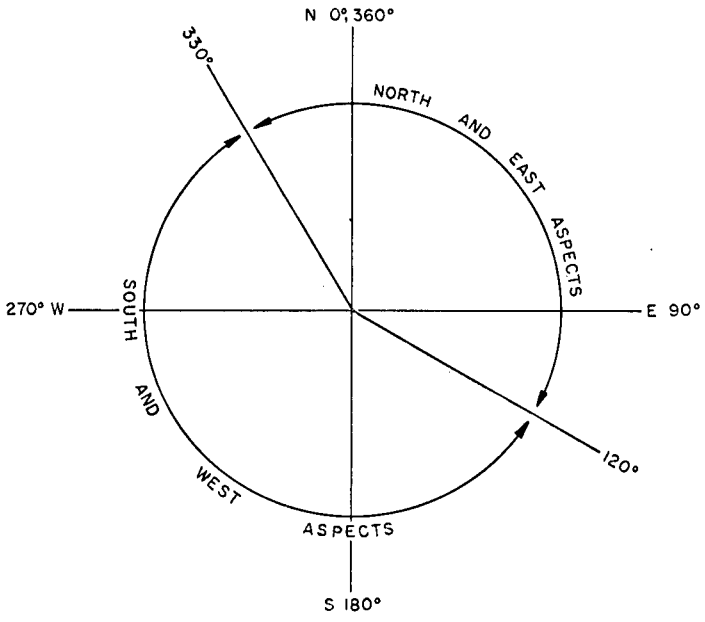

***Figure 10.*—Aspects for slopes of more than 8 percent.**

Seedling mortality is rated according to the loss of seedlings after adequate natural seeding or suitable planting. A rating of *slight* indicates trees ordinarily regenerate naturally in places where there are sufficient seeds, or that the loss is not more than 25 percent of the planted stock; *moderate* indicates that trees do not regenerate naturally in numbers adequate for restocking, or that the loss is between 25 and 50 percent of planted stock; *severe* indicates that the loss is more than 50 percent of the planted stock.

Plant competition is rated according to the degree of competition from other plants and the rate at which undesirable species invade the forest when openings are made in the canopy. A rating of *slight* indicates that unwanted plants are no special concern; *moderate* indicates that competition delays the establishment of a fully stocked stand; and *severe* indicates that competition prevents natural or artificial regeneration unless intensive control is used.

Equipment limitations are rated according to the degree to which soil characteristics restrict or prohibit tree seeding and harvesting equipment. A rating of *slight* indicates that there is little or no restriction on the type of equipment that can be used or the time of year that equipment can be used; *moderate* indicates that the use of equipment is seasonally limited, or that modified equipment or methods of harvesting are needed; and *severe* indicates that special equipment is needed or that the use of such equipment is severely restricted by unfavorable soil characteristics.

Wildlife

In this subsection the wildlife of the survey area is discussed, and the capability of the soils to establish and maintain elements of wildlife habitat is estimated. The capability of the soils to support the two broad classes of wildlife in the area is also evaluated.

Wildlife resources are important for recreational activities such as hunting, fishing, and observing and photographing wildlife.

The Mark Twain National Forest Area was originally inhabited by many kinds of wildlife. Early explorers recorded sightings of black bear, elk, bison, cougar, and passenger pigeons. These species disappeared as the area was settled. In the early 1900's deer and turkey were almost extinct in Missouri. Today, there is a moderate number of game animals, including deer, turkey, rabbit, fox and gray squirrels, quail, red and gray foxes, opossum, and raccoon. There is a limited number of beaver and muskrat along the streams. Songbirds, both resident and migratory, are abundant. There are many species of fish in both the Current and the Eleven Point Rivers. Many farm ponds are stocked with largemouth bass and bluegill.

Most species of wildlife range over a wide area that includes several kinds of soils. It is impractical to rate each soil for each wildlife species, because of the large number of animal species in the survey area. It is possible, however, to rate a particular soil on the degree to which it provides habitat to a wildlife class.

TABLE 3.—*Landsite groups and woodland suitability groups, their potential productivity, hazards and limitations, and suitable species for planting*

[The symbol < means less than]

Soil description, soil series, and map symbols	Landsite group	Woodland suitability group [1]	Potential productivity [2]		Management hazards or limitations				Species suitable for planting [4]
			Site index	Estimated average annual growth rate [3]	Erosion hazard	Seedling mortality	Plant competition	Equipment limitations	
			Ft.	*Bd. ft. per acre*					
Deep, well drained and moderately well drained, nearly level to moderately steep soils on low stream terraces and toe slopes at the foot of slopes and ridge ends: Ashton: AtB; Claiborne: CcB, CcD; Viraton: VcB.	A	3o7	66–75	250	Slight	Slight	Moderate	Slight	Sycamore, shortleaf pine.
Deep, well-drained, gently sloping to moderately steep soils on ridgetops and side slopes: Poynor: PyB, PyD.	B	4f1	56–65	200	Slight to moderate where slopes are 2 to 8 percent. Moderate where slopes are more than 8 percent.	Slight to moderate.	Slight to moderate.	Slight where slopes are 2 to 8 percent. Moderate where slopes are 8 to 14 percent.	Shortleaf pine.
Deep, well-drained, gently sloping soils on low stream terraces near drainageways: Secesh: SeB.	B	4f7	56–65	200	Slight to moderate where slopes are 2 to 8 percent.	Slight to moderate.	Slight to moderate.	Slight where slopes are 2 to 8 percent.	Shortleaf pine.
Deep, somewhat excessively drained, moderately steep soils on side slopes: Clarksville: CdD; Coulstone: ChD.	B	4f8	56–65	200	Moderate where slopes are more than 8 percent.	Slight to moderate.	Slight to moderate.	Moderate where slopes are 8 to 14 percent.	Shortleaf pine.
Deep, somewhat excessively drained and well-drained, moderately steep to very steep soils on side slopes with north and east aspects: Clarksville: CdE, CdF; Coulstone: ChE, ChF; Poynor: PyE, PyF.	B	4f9	56–65	200	Moderate where slopes are more than 8 percent.	Slight to moderate.	Slight to moderate.	Moderate where slopes are 8 to 14 percent. Severe where slopes are more than 14 percent.	Shortleaf pine.
Deep, well-drained soils that are gently sloping on ridgetops and moderately steep on side slopes; some soils have a fragipan: Captina: CaB, CbB, CbD; Doniphan: DoB, DoD; Macedonia: MaB, MaD.	B	4o7	56–65	200	Slight to moderate where slopes are 2 to 8 percent. Moderate where slopes are more than 8 percent.	Slight to moderate.	Slight to moderate.	Slight where slopes are 2 to 8 percent. Moderate where slopes are 8 to 14 percent.	Shortleaf pine.

Deep, well-drained, steep soils on side slopes: Doniphan: DoE.	B	4r9	56–65	200	Moderate where slopes are more than 8 percent.	Slight to moderate.	Slight to moderate.	Severe where slopes are more than 14 percent.	Shortleaf pine.
Deep, somewhat poorly drained, nearly level soils on first and second bottoms near drainageways: Newark: NeA.	B	4w8	56–65	200	Slight to moderate where slopes are 2 to 8 percent.	Slight to moderate.	Slight to moderate.	Slight where slopes are 2 to 8 percent.	Shortleaf pine.
Shallow, well-drained, moderately steep to very steep soils on side slopes: Opequon: OpD. OpE, OpF.	D	5d9	36–45	----------	Severe----------	Moderate-------	Moderate---	Severe----------	Redcedar.
Deep, somewhat excessively drained, gently sloping and moderately steep soils on ridgetops and side slopes: Clarksville: CdB, CdD; Coulstone: ChB, ChD.	C	5f7	46–55	125	Slight where slopes are 2 to 8 percent. Moderate where slopes are more than 8 percent.	Moderate where slopes are 2 to 8 percent. Severe where slopes are more than 8 percent.	Slight to moderate.	Slight where slopes are 2 to 8 percent.	Shortleaf pine.
Deep, moderately well drained soils with a fragipan that are gently sloping where on ridgetops and moderately steep where on side slopes: Wilderness: WdB, WdD.	C	5f8	46–55	125	Slight where slopes are 2 to 8 percent. Moderate where slopes are more than 8 percent.	Moderate where slopes are 2 to 8 percent. Severe where slopes are more than 8 percent.	Slight to moderate.	Slight where slopes are 2 to 8 percent. Moderate where slopes are 8 to 14 percent.	Shortleaf pine.
Deep, somewhat excessively drained and well-drained, moderately steep to very steep soils on side slopes with south and west aspects: Clarksville: CdE, CdF; Coulstone: ChE, ChF; Poynor: PyD, PyE, PyF.	C	5f9	46–55	125	Moderate where slopes are more than 8 percent.	Severe where slopes are more than 8 percent.	Slight to moderate.	Moderate where slopes are 8 to 14 percent. Severe where slopes are more than 14 percent.	Shortleaf pine.
Deep, somewhat excessively drained, nearly level or gently sloping soils on first bottom positions: Midco: MdB.	E	5f9	25–35	----------	Slight----------	Severe----------	Moderate---	Moderate-------	None.
Moderately steep to very steep areas with bedrock on more than 25 percent of the surface area; on side slopes: Rock land: RoD, RoE, RoF.	F	5x0	<25	----------	Severe----------	Severe----------	[1]Moderate---	Severe----------	None.

[1] Woodland suitability groups refer to the Soil Conservation Service system of evaluating soils for woodland productivity (*4*).

[2] Estimates for potential productivity are based on black oak trees.

[3] Estimates for average annual growth per acre are based on U.S. Department of Agriculture, Forest Service data (*11*).

[4] Hardwoods usually regenerate readily without planting. Walnuts are planted in selected areas. Redcedar usually regenerates easily, and no planting is necessary.

Most managed wildlife habitats are created or maintained through the manipulation of existing vegetation, the planting of suitable vegetation, the inducement of natural establishment of desirable plants, or through a combination of these measures. A knowledge of soil properties makes it possible to predict how various plant management and water management practices will affect particular soils.

In table 4 ratings are given for five elements of wildlife habitat and for two kinds of wildlife. In these ratings no consideration is given to either the size and shape of soil delineations or to the pattern that soils form on the landscape. These factors, as well as the range of the individual wildlife species, should be considered when making an evaluation of an area that includes two or more soils. The kinds and amounts of wildlife that can be produced on a soil are directly related to the type and to the amount and distribution of vegetation over a given area. Most wildlife species make use of different soils for different purposes. They may nest on one soil, feed on another, and find protective cover on still another. Several kinds of soil within the range of a given wildlife species generally provide the best habitat.

In table 4 the soils in the survey area are rated good, fair, poor, and very poor. *Good* indicates that habitat generally is easily created, maintained, or improved, and that there are few if any limitations to habitat management. Satisfactory results can be expected. *Fair* indicates that habitat generally can be created, maintained, or improved, but that there are moderate limitations to habitat management or development. A moderate intensity of management and fairly frequent attention may be required to assure satisfactory results. *Poor* indicates that habitat generally can be created, maintained, or improved, but that there are severe limitations. Habitat management may be difficult, expensive, and may require intensive efforts. Results are questionable. *Very poor* indicates that it is impractical to attempt to create, maintain, or improve habiat under the prevailing conditions. Unsatisfactory results are probable.

In the following paragraphs the five elements of wildlife habitat and the two kinds of wildlife rated in table 4 are briefly defined.

Grain and seed crops are domestic grains or annual, herbaceous, seed-producing plants used to produce food for wildlife. Examples are corn, sorghum, wheat, oats, millet, buckwheat, and sunflower.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are used to furnish wildlife food and cover. Examples are timothy, redtop, orchard, clovers, alfalfa, and sericea lespedeza.

Hardwood trees are trees that produce fruit, nuts, buds, foliage, or twigs, that are used extensively as food for wildlife. They are established commonly through natural processes but also may be planted. Examples are oak, cherry, dogwood, maple, and persimmon.

Coniferous plants are cone-bearing trees and shrubs of primary importance to wildlife as cover. They also may furnish food in the form of browse, seeds, or fruitlike cones. They are established commonly through natural processes but also may be planted. Examples are shortleaf pine and redcedar.

Wild herbaceous plants are perennial grasses and forbs used principally as food and cover for upland wildlife. They are established mainly through natural processes but also may be planted. Examples are bluestem, indiangrass, wheatgrass, wildrye, oatgrass, pokeweed, strawberry, lespedeza, beggarweed, goldenrod, and dandelion.

Woodland wildlife includes birds and mammals that normally frequent wooded areas of hardwood trees and shrubs, coniferous trees and shrubs, or a mixture of such plants. Examples are fox and gray squirrel, gray fox, turkey, deer, raccoon, opossum, and woodpecker.

Open-land wildlife includes birds and mammals that normally frequent cropland, pastures, meadows, lawns, and areas overgrown with grasses, herbs, and shrubby growth. Examples of this kind of wildlife are quail, meadowlark, field sparrow, rabbit, red fox, woodchuck, and red-tailed hawk.

Rating soils for the production of wildlife habitat aids in the selection of sites for habitat management and indicates the management intensity needed to produce satisfactory results. It is a means of placing soils in groups according to soil conditions for wide-scale wildlife land-use planning. In conjunction with soil maps, these ratings are an aid to wildlife managers in the selection of areas in which to apply management practices and in the selection of practices to apply.

The information given in table 4 does not eliminate the need for onsite evaluation of soils for wildlife production. The pattern of soil delineations and the plant cover must be considered in all onsite investigations. The degree of limitations and the restrictions given are intended only to provide guidance in the selection and development of suitable sites for wildlife habitat and are based on the present state of knowledge.

Recreational Uses of the Soils

The Mark Twain National Forest Area has many areas of scenic, geologic, and historic interest. These areas are suitable for camping, hiking, hunting, fishing, floating, and sightseeing (fig. 11). Some areas that have been established for recreation are Hawes Memorial, Watercress Spring, Greer Crossing, Whites Creek, Buffalo Creek, Deer Leap, McCormack Lake, and Ripley Lake.

An evaluation of the soils in the survey area for specific recreational purposes is given in table 5. These evaluations are expressed in terms of degree of limitation. They are predictions of the behavior of specific soils for specific kinds of recreational uses. Planners will need to consider these factors in making a final use evaluation. The evaluations given do not eliminate the need for onsite investigation.

The evaluations in table 5 are intended to provide a general guide to the selection of suitable sites and to assist in the orderly development of recreational uses listed in the table. The information on soils may be equally useful in determining the suitability of the soils for many other related forms of recreation. The sections "Engineering Uses of the Soils," "Management of the Soils for Timber," "Hydrology," and "Wildlife" also are helpful in planning recreational facilities.

TABLE 4.—*Suitability of soils for wildlife habitat and for kinds of wildlife*

Soil series and map symbols	Elements of wildlife habitat					Kinds of wildlife	
	Grain and seed crops	Grasses and legumes	Hardwood trees	Coniferous plants	Wild herbaceous plants	Woodland	Open-land
Alluvial land, loamy: Aa.	Very poor: flooding.	Very poor: flooding.	Poor: low available water capacity.	Poor: flooding.	Fair: flooding.	Poor	Poor.
Alluvial land, mixed: Am.	Very poor: flooding.	Very poor: flooding.	Poor: low available water capacity.	Poor: flooding.	Fair: flooding.	Poor	Poor.
Ashton: AtB	Good	Good	Good	Good	Good	Good	Good.
Captina:							
CaB	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Good	Good	Good	Fair	Good.
CbB	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair	Fair.
CbD	Fair: fragipan at depth of less than 30 inches; slope.	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair: fragipan at depth of less than 30 inches.	Fair	Fair.
Claiborne:							
CcB	Good	Good	Good	Good	Good	Good	Good.
CcD	Fair: slope	Good	Good	Good	Good	Good	Good.
Clarksville:							
CdB	Poor: very low to low available water capacity; coarse fragments.	Poor: very low to low available water capacity; coarse fragments.	Fair: very low to low available water capacity.	Fair: very low to low available water capacity.	Poor: coarse fragments.	Fair	Poor.
CdD, CdE, CdF.	Poor: very low to low available water capacity; coarse fragments; slope.	Poor: coarse fragments; slope; very low to low available water capacity.	Fair: very low to low available water capacity.	Fair: very low to low available water capacity.	Poor: coarse fragments.	Fair	Poor.
Coulstone:							
ChB	Poor: very low to low available water capacity; coarse fragments.	Poor: very low to low available water capacity; coarse fragments.	Fair: very low to low available water capacity.	Fair: very low to low available water capacity.	Poor: coarse fragments.	Fair	Poor.
ChD, ChE, ChF.	Poor: very low to low available water capacity; coarse fragments; slope.	Poor: coarse fragments; slope; very low to low available water capacity.	Fair: very low to low available water capacity.	Fair: very low to low available water capacity.	Poor: coarse fragments.	Fair	Poor.
Coulstone-Clarksville-Rockland: CvD, CvE, CvF. See individual soil series.							

TABLE 4.—*Suitability of soils for wildlife habitat and for kinds of wildlife*—Continued

Soil series and map symbols	Elements of wildlife habitat					Kinds of wildlife	
	Grain and seed crops	Grasses and legumes	Hardwood trees	Coniferous plants	Wild herbaceous plants	Woodland	Open-land
Doniphan:							
DoB, DoD	Poor: coarse fragments.	Poor: coarse fragments.	Good	Good	Good	Fair	Fair.
DoE	Very poor: slope.	Poor: coarse fragments.	Good	Good	Good	Fair	Fair.
Macedonia: MaB, MaD.	Fair: slope	Good	Good	Good	Good	Good	Good.
Midco: MdB	Very poor: very low available water capacity; coarse fragments.	Very poor: very low available water capacity; coarse fragments.	Poor: very low available water capacity.	Fair: very low available water capacity.	Poor: coarse fragments; very low available water capacity.	Poor	Poor.
Newark: NeA	Fair: drainage	Good	Good	Good	Good	Good	Good.
Opequon:							
OpD	Poor: shallow depth to bedrock; slope; very low available water capacity.	Poor: shallow depth to bedrock.	Fair: shallow depth to bedrock.	Fair: shallow depth to bedrock.	Poor: shallow depth to bedrock; very low available water capacity.	Fair	Fair.
OpE, OpF	Very poor: slope.	Poor: shallow depth to bedrock; slope.	Fair: shallow depth to bedrock.	Fair: shallow depth to bedrock.	Poor: shallow depth to bedrock; very low available water capacity.	Fair	Fair.
Poynor:							
PyB, PyD	Poor: coarse fragments.	Poor: coarse fragments.	Fair: low to moderate available water capacity.	Fair: low to moderate available water capacity.	Fair: low to moderate available water capacity.	Fair	Poor.
PyE, PyF	Very poor: slope.	Poor: slope; coarse fragments.	Fair: low to moderate available water capacity.	Fair: low to moderate available water capacity.	Fair: low to moderate available water capacity.	Fair	Poor.
Rock land: RoD, RoE, RoF.	Very poor: very shallow and shallow depth; rockiness.	Very poor: very shallow and shallow depth; rockiness.	Very poor: very shallow and shallow depth; rockiness.	Very poor: very shallow and shallow depth; rockiness.	Very poor: very shallow and shallow depth; rockiness.	Very poor.	Very poor.
Secesh: SeB	Good	Good	Good	Good	Good	Good	Good.
Viraton: VcB	Fair: fragipan in subsoil.	Good	Good	Good	Good	Good	Good.
Wilderness: WdB, WdD.	Poor: low available water capacity; coarse fragments.	Poor: low available water capacity; coarse fragments.	Fair: fragipan at depth of 15 to 22 inches; low available water capacity.	Fair: fragipan at depth of 15 to 22 inches; low available water capacity.	Fair: depth; fragipan at depth of 15 to 22 inches; low available water capacity.	Fair	Poor.

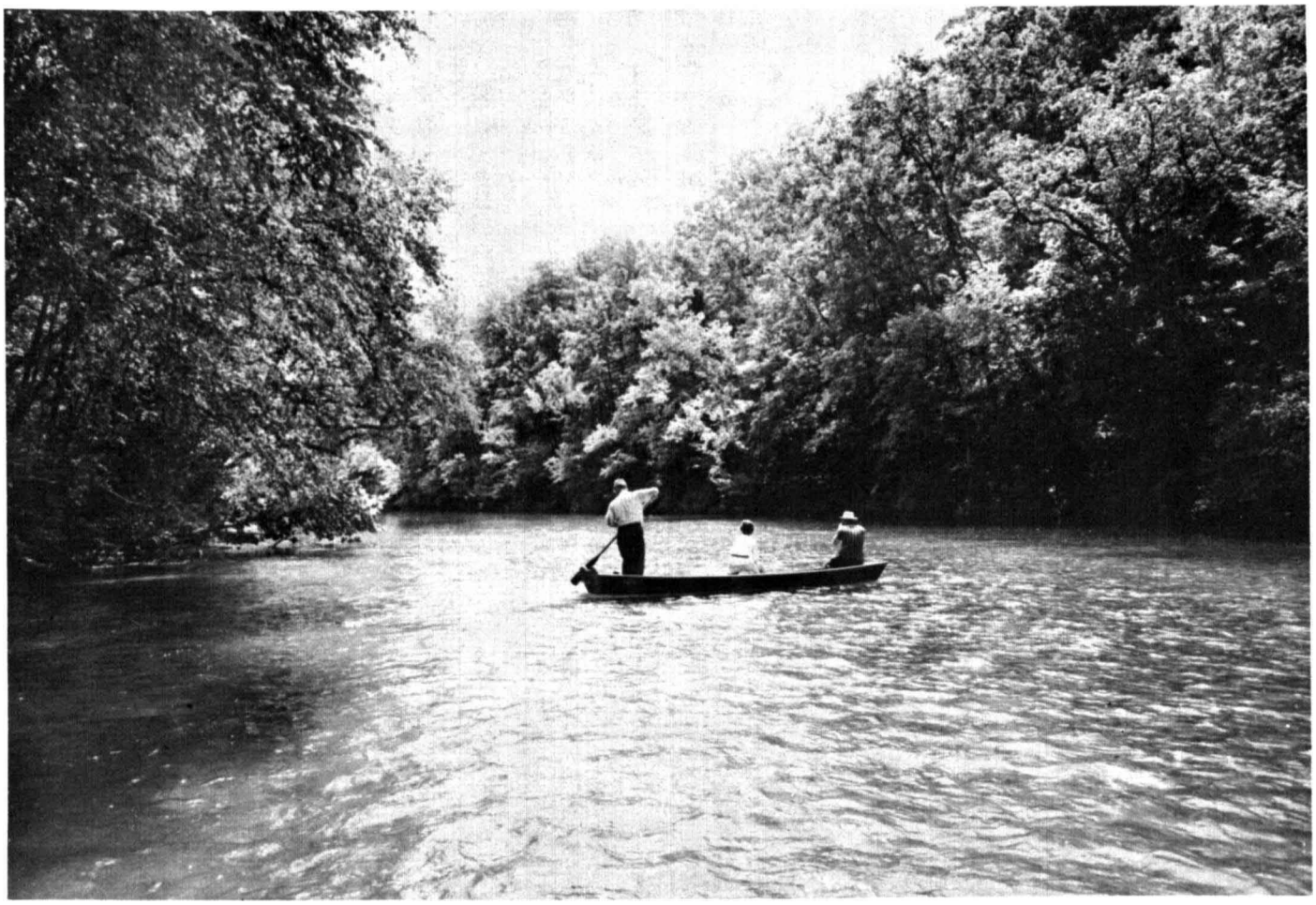

***Figure 11.*—Floating the clear, swift streams is a major recreational activity.**

The soils best suited to recreational facilities are generally deep, well-drained, gently sloping, moderately permeable to rapidly permeable soils, such as Secesh loam. Silty clays and other fine-textured soils are less desirable than coarse-textured soils because they are more susceptible to compaction, puddling, and erosion. Cherty soils, such as Midco cherty loam, are not desirable for picnic areas and campsites. They are droughty and do not readily support the plant cover that is needed in most of the areas used intensively for recreation.

Soils that are relatively free of limitations or that have limitations that can be overcome easily are rated as having slight limitations for a specific recreational use. Soils that can be used under good management and with careful design are rated as having moderate limitations for specific uses. Soils that have limitations that are difficult to overcome or areas of soil where the suitability is questionable, or generally unsound, are rated as having severe limitations for specific uses. In addition to the ratings given for each soil for specific recreational uses, a listing of hazards or limitations is given. Only the major hazards are listed.

Picnic areas.—The evaluations in this column apply to soils used seasonally for picnic areas. The most desirable soils are nearly level to gently sloping, well drained, free of coarse fragments, free from flooding during the use period, have a texture and consistence that provide a firm surface, and have the capacity to support a good and varied plant cover.

Playgrounds.—The evaluations in this column apply to soils used for playgrounds, athletic fields, and other intensive play areas. Areas selected for these uses are subject to intensive foot traffic and should be able to support protective vegetation. The most desirable soils are nearly level, well drained, free of coarse fragments and hard rock, and free from flooding, and have a texture and consistence that provide a firm surface. Soils with less desirable properties in the surface layer require more preparation and maintenance.

Campsites for intensive use.—The evaluations in this column apply to soils used for sites for tents and small camp trailers and for the accompanying activities of outdoor living. The soils should be suitable for heavy foot traffic and for limited vehicular traffic. The limitation of the soil for growing traffic-bearing vegetation is an important consideration. The most desirable soils are level

to gently sloping, are free of coarse fragments, have an adequate plant cover that is easy to maintain, and are not subject to erosion.

Paths and trails.—The evaluations in this column apply to soils used for paths, trails, bridle paths, cross-country hiking, and other intensive uses. The evaluations were made in areas where little or no cutting and filling are required. The most desirable soils have good foot and hoof trafficability, are well drained, have good stability, are not subject to erosion, and are free of coarse fragments. Some of these recreational areas may be of outstanding esthetic appeal. Consideration should be given to the placement of paths and trails on the contour to reduce the hazard of erosion. The slope of paths and trails should not exceed 14 percent for prolonged distances. Potential for growing plants is important in the areas bordering the trails and paths.

Cottages and utility buildings.—The evaluations in this column apply to soils used both seasonally and all year for recreational buildings such as cottages, washrooms and bathhouses, picnic shelters, and service buildings. The limitations are severe if the soils are used for septic tank filter fields and they are slowly permeable, poorly drained, shallow to bedrock, subject to flooding, or steeply sloping. Refer to the section "Engineering Uses of the Soils" for ratings for sanitary facilities.

TABLE 5.—*Limitations of the soils for some recreational uses*

[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. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

Soil series and map symbols	Picnic areas	Playgrounds	Campsites for intensive use	Paths and trails	Cottages and utility buildings
Alluvial land, loamy: Aa	Severe: flooding	Severe: flooding	Severe: flooding	Severe: flooding	Severe: flooding.
Alluvial land, mixed: Am	Severe: flooding	Severe: flooding	Severe: flooding	Severe: flooding	Severe: flooding.
Ashton: AtB	Moderate: flooding.	Moderate: flooding.	Severe: flooding	Slight	Severe: flooding.
Captina:					
CaB	Slight	Moderate: seasonal wetness; slope.	Moderate: seasonal wetness.	Slight	Severe: seasonal wetness; fragipan at a depth of 17 to 30 inches.
CbB	Moderate: seasonal wetness.	Moderate: seasonal wetness; slope.	Moderate: seasonal wetness.	Slight	Severe: seasonal wetness; fragipan at a depth of 17 to 30 inches.
CbD	Moderate: seasonal wetness; slope.	Severe: slope	Moderate: seasonal wetness; slope.	Slight	Severe: seasonal wetness; fragipan at a depth of 17 to 30 inches.
Claiborne:					
CcB	Slight	Moderate: slope.	Slight	Slight	Slight.
CcD	Moderate: slope	Severe: slope	Moderate: slope.	Slight	Moderate: slope.
Clarksville:					
CdB	Moderate: coarse fragments.	Severe: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.
CdD	Moderate: coarse fragments; slope.	Severe: coarse fragments; slope.	Moderate: coarse fragments; slope.	Moderate: coarse fragments.	Moderate: coarse fragments; slope.
CdE	Severe: slope	Severe: slope; coarse fragments.	Severe: slope	Moderate: coarse fragments; slope.	Severe: slope.
CdF	Severe: slope	Severe: slope; coarse fragments.	Severe: slope	Severe: slope	Severe: slope.
*Coulstone:					
ChB	Moderate: coarse fragments.	Severe: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.

TABLE 5.—*Limitations of the soils for some recreational uses*—Continued

Soil series and map symbols	Picnic areas	Playgrounds	Campsites for intensive use	Paths and trails	Cottages and utility buildings
*Coulstone—Con.					
ChD, CvD	Moderate: coarse fragments; slope.	Severe: coarse fragments; slope.	Moderate: coarse fragments; slope.	Moderate: coarse fragments.	Moderate: coarse fragments; slope.
ChE, CvE	Severe: slope	Severe: slope; coarse fragments.	Severe: slope	Moderate: coarse fragments; slope.	Severe: slope.
ChF, CvF	Severe: slope	Severe: slope; coarse fragments.	Severe: slope	Severe: slope	Severe: slope.
For Clarksville properties of CvD, CvE, and CvF, refer to Clarksville units CdD, CdE, and CdF, respectively; for Rock land properties of CvD, CvE, and CvF, refer to Rock land units RoD, RoE, and RoF, respectively.					
Doniphan:					
DoB	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.
DoD	Moderate: coarse fragments; slope.	Severe: slope	Moderate: coarse fragments; slope.	Moderate: coarse fragments.	Moderate: coarse fragments; slope.
DoE	Severe: slope	Severe: slope	Severe: slope	Moderate: slope; coarse fragments.	Severe: slope.
Macedonia:					
MaB	Slight	Moderate: slope.	Slight	Slight	Slight.
MaD	Moderate: slope.	Severe: slope	Moderate: slope.	Slight	Moderate: slope.
Midco: MdB	Moderate: flooding.	Moderate: flooding; coarse fragments.	Severe: flooding; coarse fragments.	Slight	Severe: flooding.
Newark: NeA	Severe: flooding; seasonal wetness.	Severe: flooding; seasonal wetness.	Severe: flooding; seasonal wetness.	Severe: flooding; seasonal wetness.	Severe: flooding; seasonal wetness.
Opequon:					
OpD	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Moderate: rockiness.	Severe: shallow to bedrock; rockiness.
OpE	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Moderate: rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.
OpF	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.
Poynor:					
PyB	Moderate: coarse fragments.	Severe: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments.
PyD	Moderate: coarse fragments; slope.	Severe: coarse fragments; slope.	Moderate: coarse fragments; slope.	Moderate: coarse fragments.	Moderate: coarse fragments; slope.
PyE	Severe: slope	Severe: slope; coarse fragments.	Severe: slope	Moderate: coarse fragments; slope.	Severe: slope.
PyF	Severe: slope	Severe: slope; coarse fragments.	Severe: slope	Severe: slope	Severe: slope.

TABLE 5.—*Limitations of the soils for some recreational uses*—Continued

Soil series and map symbols	Picnic areas	Playgrounds	Campsites for intensive use	Paths and trails	Cottages and utility buildings
Rock land:					
RoD	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Moderate: rockiness.	Severe: shallow to bedrock; rockiness.
RoE	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Moderate: rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.
RoF	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.	Severe: rockiness; slope.	Severe: shallow to bedrock; rockiness; slope.
Secesh: SeB	Slight	Slight	Slight	Slight	Moderate: flooding.
Viraton: VcB	Moderate: seasonal wetness.	Moderate: seasonal wetness.	Moderate: seasonal wetness.	Moderate: seasonal wetness.	Moderate: seasonal wetness.
Wilderness:					
WdB	Moderate: coarse fragments.	Moderate: coarse fragments.	Moderate: coarse fragments; fragipan at depth of 15 to 22 inches.	Slight	Moderate: fragipan at depth of 15 to 22 inches.
WdD	Moderate: coarse fragments.	Severe: slope	Moderate: coarse fragments; fragipan at depth of 15 to 22 inches; slope.	Slight	Moderate: fragipan at depth of 15 to 22 inches; slope.

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, land developers, engineers, 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 kinds of soil on which they are built, for the purpose of predicting 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.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 6, 7, and 8, and 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 those shown in the tables, generally 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 is not known to all engineers. The Glossary defines many of these terms commonly used in soil science.

Most of the information in this subsection is in tables 6, 7, and 8, but additional information useful to engineers can be found in other sections of this survey, particularly in the sections "Descriptions of the Soils" and in "Recreational Uses of the Soils."

Engineering test data

Table 6 contains the results of engineering tests performed by the Missouri State Highway Commission, Division of Materials and Research, on eight soils in the survey area. The table shows the specific location where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Moisture-density (or compaction) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the optimum moisture content is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test in termed maximum dry density. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Engineering soil classifications in table 6 are based on data obtained by mechanical analysis and on the results of tests made to determine the liquid limit and plasticity index of the soils. Mechanical analysis shows the percentages, by weight, of soil particles that would pass sieves of specified sizes. Sand and other coarser materials do not pass through the No. 200 sieve. Silt and clay passing through the No. 200 sieve were determined by the hydrometer method rather than by the pipette method most soil scientists use in determining the clay in soil samples.

The results of the mechanical analysis may be used to determine the relative proportions of the different-sized particles. The clay content obtained by the hydrometer method should not be used in naming soil textural classes.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*12*), used by the SCS engineers, Department of Defense, and others, and the AASHO system (*1*), adopted by the American Association of State Highway Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL.

The AASHO system is used to classify soils according to those properties that affect use in highway construction 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, 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 AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 6, the estimated classification, without group index numbers, is given in table 7 for all soils mapped in the survey area.

Engineering properties

Several estimated soil properties significant in engineering are given in table 7 .These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. 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 soil in other counties (*9*, *10*). Following are explanations of some of the columns in table 7.

Depth to bedrock is distance from the surface of the soil to the upper surface of the rock layer.

Depth to the seasonal high water table was not estimated. Except for the Captina and Newark soils, the seasonal water table is generally more than 60 inches.

Soil texture is described in table 7 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. 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 at the back of this soil survey.

Permeability is the quality of the soil that enables it to transmit water and air. In table 7 permeability is estimated for undisturbed soil material in inches of water percolation per hour. The estimates are based on soil structure and consistence and on field observations. Limited laboratory data were also available.

Available water capacity, estimated in inches per inch of soil depth, is the amount of moisture that the soil can hold in a form that is readily available to plants. It is the difference between the amount of moisture in a soil at field capacity and the amount in the soil at the wilting point of most crop plants.

TABLE 6.—*Engineering*

[Tests performed by the Missouri State Highway

Soil name and location	Parent material	Missouri report number	Depth from surface	Moisture-density data [2]	
				Maximum dry density	Optimum moisture
			In.	*Lb. per cu. ft.*	*Pct.*
Ashton silt loam:					
NE¼NE¼ sec. 4, T. 25 N., R. 3 W. (Modal profile)	Alluvium.	70–15508	0–8	103	16
		70–15509	16–36	112	14
		70–15510	36–60	113	15
Doniphan cherty silt loam:					
SW¼NW¼ sec. 31, T. 25 N., R. 1 W. (Modal profile)	Cherty dolomite.	70–15511	0–4	104	17
		70–15512	11–20	89	29
		70–15513	28–60	83	33
Macedonia silt loam:					
SE¼NW¼ sec. 31, T. 25 N., R. 1 W. (Modal profile)	Cherty dolomite with loess mantle.	70–15514	0–2	105	16
		70–15515	6–14	113	16
		70–15516	48–66	88	31
Midco cherty loam:					
NW¼NW¼ sec. 13, T. 26 N., R. 3 W. (Modal profile)	Alluvium.	70–15523	0–8	114	12
		70–15524	8–17	122	12
Poynor cherty silt loam:					
NE¼SE¼ sec. 5, T. 23 N., R. 2 W. (Modal profile)	Cherty dolomite.	70–15517	4–10	117	13
		70–15518	18–28	106	17
		70–15519	40–60	88	31
Secesh loam:					
SW¼NW¼ sec. 4, T. 25 N., R. 2 W. (Modal profile)	Alluvium.	70–15520	0–8	117	13
		70–15521	27–39	118	13
		70–15522	39–51	119	12
Viraton silt loam:					
SW¼NE¼ sec. 34, T. 26 N., R. 2 W. (Modal profile)	Colluvium.	70–15525	0–4	113	13
		70–15526	10–15	103	19
		70–15527	52–60	106	19
Wilderness cherty silt loam:					
SE¼SW¼ sec. 15, T. 26 N., R. 3 W. (Modal profile)	Cherty dolomite with loess mantle.	70–15528	0–6	110	15
		70–15529	17–27	118	12
		70–15530	38–60	97	26

[1] Data for a typical Clarksville soil is in the Soil Survey of Dent County, Missouri (*10*), and for a typical Captina soil in the Soil Survey of Washington County, Arkansas (*9*).

[2] Based on AASHO Designation T 99–57, Method C. (*1*).

[3] Mechanical analyses according to AASHO Designation T 88–54 (*1*). Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method, and various grain-size fractions are calculated on the basis of all the material, including that coarser than 2

test data [1]

Commission, Division of Materials and Research]

Mechanical analysis [3]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than—					
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.005 mm.	0.001 mm., approx.			AASHO [4]	Unified [5]
						Pct.			
100	100	99	96	25	8	29	5	A-4(8)	ML
100	100	99	96	34	18	28	8	A-4(8)	CL
100	100	99	95	35	19	28	8	A-4(8)	CL
74	65	59	50	14	6	30	3	A-4(3)	GM
99	99	98	95	80	68	65	34	A-7-5(20)	CH
93	91	88	86	72	61	69	31	A-7-5(20)	CH
99	97	89	79	22	8	25	[6] NP	A-4(8)	ML
89	82	76	70	34	23	38	18	A-6(10)	CL
100	100	98	95	78	59	76	41	A-7-5(20)	CH
85	80	71	38	14	9	20	1	A-4(1)	SM
53	44	36	20	8	4	19	4	A-1-6(10)	GM
93	90	81	58	20	6	23	6	A-4(5)	ML
69	65	59	49	32	25	43	23	A-7-6(20)	GC
100	100	99	92	79	63	68	33	A-7-5(20)	MH
97	96	84	47	17	6	21	3	A-4(2)	SM
76	71	59	30	22	10	28	12	A-2-6(0)	SC
68	62	49	20	13	9	25	8	A-2-4(0)	SC
99	98	93	67	21	9	22	3	A-4(6)	ML
97	95	92	80	44	31	46	22	A-7-6(14)	CL
100	99	96	83	43	30	41	21	A-7-6(12)	CL
99	97	92	70	20	6	21	NP	A-4(7)	ML
66	51	46	35	14	7	25	9	A-2-4(10)	GC
81	79	76	69	51	40	50	22	A-7-6(14)	CL

millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for naming textural classes for soils.

[4] Based on AASHO Designation M 145-49 (*1*).

[5] Based on ASTM Designation D 2487-66T (*12*).

[6] Nonplastic.

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. The soils in referring to other series that appear in the first column of this table.

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification
			USDA texture
	Inches	*Inches*	
Alluvial land, loamy: Aa. Too variable to be rated.			
Alluvial land, mixed: Am. Too variable to be rated.			
Ashton: AtB	>60	0–16	Silt loam
		16–60	Silt loam
Captina: CaB, CbB, CbD	>60	0–16	Silt loam
		16–28	Silty clay loam
		28–32	Silty clay loam (fragipan)
		32–55	Cherty silty clay loam (fragipan)
Claiborne: CcB, CcD	>60	0–13	Silt loam
		13–66	Silty clay loam
Clarksville: CdB, CdD, CdE, CdF	>60	0–13	Cherty silt loam
		13–60	Cherty silty clay loam
*Coulstone: ChB, ChD, ChE, ChF, CvD, CvE, CvF For Clarksville properties of CvD, CvE, and CvF, refer to Clarksville series; Rock land part of CvD, CvE, and CvF is too variable to be rated.	>60	0–19	Cherty fine sandy loam
		19–40	Cherty sandy clay loam
		40–60	Cherty clay
Doniphan: DoB, DoD, DoE	>60	0–6	Cherty silt loam to silt loam
		6–11	Silty clay
		11–60	Clay
Macedonia: MaB, MaD	>60	0–14	Silt loam
		14–48	Cherty silty clay or silty clay
		48–66	Cherty clay
Midco: MdB	>60	0–8	Cherty loam
		8–17	Cherty loam
		17–26	Cherty coarse sandy loam
		26–60	Cherty coarse sandy loam
Newark: NeA	>60	0–11	Silt loam
		11–36	Silt loam
		36–55	Silt clay loam
Opequon: OpD, OpE, OpF	<20	0–5	Cherty silty clay loam
		5–19	Clay or cherty clay
Poynor: PyB, PyD, PyE, PyF	>60	0–10	Cherty silt loam
		10–28	Cherty silty clay
		28–60	Clay
Rock land: RoD, RoE, RoF. Too variable to be rated.			
Secesh: SeB	>60	0–11	Loam
		11–39	Silty clay loam, cherty sandy clay loam
		39–65	Cherty sandy clay loam
Viraton: VcB	>60	0–4	Silt loam
		4–15	Silty clay loam
		15–20	Cherty silty clay loam
		20–34	Cherty silty clay loam (fragipan)
		34–60	Silty clay loam (fragipan)

See footnote at end of table.

significant to engineering

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for
The symbol < means less than; the symbol > means more than]

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
ML	A-4	100	100	85-100	0. 6-2. 0	0. 22-0. 24	6. 1-6. 5	Low.
ML	A-4	100	100	85-100	0. 6-2. 0	0. 20-0. 22	6. 1-6. 5	Low.
ML	A-4	85-100	85-100	70-90	0. 6-2. 0	0. 22-0. 24	5. 1-6. 0	Low.
ML-CL	A-4, A-6	85-100	85-100	80-95	0. 2-0. 6	0. 18-0. 20	5. 1-5. 5	Moderate.
ML-CL	A-4, A-6	85-100	85-100	75-85	0. 06-0. 2	(1)	4. 5-5. 0	Moderate.
ML-CL or GM-GC	A-4, A-6	50-70	50-70	40-60	0. 06-0. 2	(1)	4. 5-5. 0	Moderate.
ML or CL	A-4, A-6	85-100	85-100	70-90	0. 6-2. 0	0. 22-0. 24	5. 1-6. 0	Low.
CL	A-6	85-100	85-100	80-95	0. 6-2. 0	0. 18-0. 20	4. 5-5. 0	Moderate.
SM, GM, ML	A-4, A-2	55-80	45-65	20-60	2. 0-6. 0	0. 05-0. 12	5. 1-6. 0	Very low.
SM, SC, GM, GC	A-2, A-4	55-80	45-70	10-50	2. 0-6. 0	0. 05-0. 10	4. 5-5. 0	Moderate.
SM	A-4, A-2	60-80	50-70	15-50	2. 0-6. 0	0. 06-0. 09	5. 1-6. 0	Very low.
SC, GC	A-2, A-4	45-70	30-60	15-45	2. 0-6. 0	0. 04-0. 09	4. 5-5. 0	Low.
CL, GC, SC	A-6	60-80	50-75	35-60	2. 0-6. 0	0. 05-0. 10	4. 5-5. 0	Moderate.
ML, SM, or GM	A-4	60-90	40-65	45-60	2. 0-6. 0	0. 08-0. 14	5. 1-6. 0	Low.
CH	A-7	85-100	85-100	85-95	0. 6-2. 0	0. 11-0. 13	4. 5-5. 5	Moderate.
CH	A-7	95-100	85-100	70-95	0. 6-2. 0	0. 09-0. 11	4. 5-5. 5	Moderate.
ML	A-4	85-100	70-95	50-85	0. 6-2. 0	0. 22-0. 24	5. 1-6. 0	Low.
CH	A-7	70-100	60-90	50-85	0. 6-2. 0	0. 05-0. 11	4. 5-5. 5	Moderate.
CH	A-7	85-100	75-100	75-100	0. 6-2. 0	0. 05-0. 11	4. 5-5. 5	Moderate.
SM	A-4	80-90	75-85	35-45	2. 0-20. 0	0. 10-0. 12	6. 1-6. 5	Very low.
SM, GM	A-1	50-60	40-50	15-25	2. 0-20. 0	0. 04-0. 06	5. 6-6. 0	Very low.
SM, GM	A-2-4	65-75	55-65	25-35	6. 0-20. 0	0. 04-0. 06	5. 6-6. 0	Very low.
GM	A-1	20-30	15-25	10-15	6. 0-20. 0	0. 01-0. 02	5. 6-6. 0	Very low.
ML	A-4	85-100	85-100	85-100	0. 6-2. 0	0. 22-0. 24	6. 1-6. 5	Low.
ML	A-4	85-100	85-100	85-100	0. 6-2. 0	0. 22-0. 24	6. 6-7. 3	Low.
CL	A-7	85-100	85-100	85-95	0. 6-2. 0	0. 18-0. 20	6. 6-7. 3	Moderate.
MH	A-7	75-85	75-85	60-70	0. 6-2. 0	0. 14-0. 16	6. 1-7. 3	Moderate.
CL	A-7	80-90	80-90	60-70	0. 2-0. 6	0. 08-0. 10	6. 1-7. 3	High.
ML, SM	A-4	80-95	70-95	45-60	2. 0-6. 0	0. 12-0. 14	4. 5-6. 5	Low.
CH, GC, SC	A-7	70-85	50-75	25-55	0. 6-2. 0	0. 05-0. 07	4. 5-6. 0	Moderate.
MH	A-7	85-100	85-100	75-95	0. 6-2. 0	0. 08-0. 10	4. 5-6. 0	Moderate.
ML	A-4	95-100	85-100	50-65	0. 6-2. 0	0. 18-0. 20	5. 6-6. 5	Low.
SC, SM	A-2 or A-4	60-85	50-80	25-50	0. 6-2. 0	0. 12-0. 14	5. 6-6. 5	Low.
SC, GC	A-1	30-65	25-55	15-25	2. 0-6. 0	0. 02-0. 04	4. 5-5. 5	Low.
ML	A-4	85-100	75-100	50-90	0. 6-2. 0	0. 20-0. 22	5. 1-6. 5	Low.
CL	A-7	85-100	75-100	50-90	0. 6-2. 0	0. 18-0. 20	5. 1-6. 5	Moderate.
CL, SC	A-7	70-100	65-100	45-85	0. 6-2. 0	0. 14-0. 16	5. 1-5. 5	Moderate.
CL, SC, GM, GC	A-7	55-85	45-75	35-75	0. 06-0. 2	0. 05-0. 08	4. 5-5. 0	Moderate.
CH, CL	A-7	85-100	85-100	75-90	0. 06-0. 2	0. 05-0. 08	4. 5-5. 0	Moderate.

TABLE 7.—*Estimated soil properties*

Soil series and map symbols	Depth to bedrock	Depth from surface	Classification
			USDA texture
Wilderness: WdB, WdD	*Inches* >60	*Inches* 0–6	Cherty silt loam
		6–17	Cherty silty clay loam
		17–27	Cherty silt loam (fragipan)
		27–38	Cherty silty clay loam (fragipan)
		38–60	Cherty silty clay

[1] No available water capacity estimates given for fragipan or layers below.

TABLE 8.—*Engineering*

[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. The soils for referring to other series that appear

Soil series and map symbols	Suitability as a source of—			
	Topsoil	Sand	Gravel	Road fill
Alluvial land, loamy: Aa	Too variable to be rated	Too variable to be rated.	Too variable to be rated.	Too variable to be rated
Alluvial land, mixed: Am	Too variable to be rated	Too variable to be rated.	Too variable to be rated.	Too variable to be rated
Ashton: AtB	Good	Unsuited	Unsuited	Fair: low strength
Captina: CaB	Good in surface layer	Unsuited	Unsuited	Fair to poor: low strength.
CbB, CbD	Good in surface layer	Unsuited	Unsuited	Fair to poor
Claiborne: CcB, CcD	Fair: thin surface layer.	Unsuited	Unsuited	Fair: moderate shrink-swell potential.
Clarksville: CdB, CdD, CdE, CdF	Unsuited	Unsuited	Unsuited	Good

significant to engineering—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM, ML	A-4	80–100	80–98	40–75	0. 6–2. 0	0. 16–0. 18	5. 6–6. 0	Very low.
SM, SC	A-6	60–80	40–65	30–50	0. 6–2. 0	0. 09–0. 12	5. 6–6. 0	Low.
GM	A-1	30–40	15–30	10–20	0. 06–0. 2	(1)	4. 5–5. 0	Very low.
GC	A-2-6	25–45	15–30	10–20	0. 06–0. 2	(1)	4. 5–5. 0	Low.
GM, GC	A-2-7	20–60	15–45	10–20	0. 6–2. 0	(1)	4. 5–5. 0	Moderate.

interpretations

in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions in the first column of this table]

Soil features affecting—		Degree and kind of limitation for—		
Ponds		Sanitary landfill (trench type)	Septic tank absorption fields	Sewage lagoons
Reservoir	Embankment			
Too variable to be rated.	Too variable to be rated.	Severe: flooding	Severe: flooding; ground water subject to contamination.	Severe: flooding; ground water subject to contamination.
Too variable to be rated.	Too variable to be rated.	Severe: flooding	Severe: flooding; ground water subject to contamination.	Severe: flooding; ground water subject to contamination.
Moderate permeability	Fair to poor compaction characteristics.	Severe: flooding	Severe: flooding	Severe: flooding.
Fragipan at a depth of about 28 inches.	Medium compacted permeability.	Severe: seasonal perched water table above fragipan; cherty fragipan.	Severe: slowly permeable fragipan.	Moderate: seasonal perched water table above fragipan; slope.
Fragipan at a depth of about 20 inches.	Medium compacted permeability.	Severe: seasonal perched water table above fragipan; cherty fragipan.	Severe: slowly permeable fragipan.	Moderate for CbB: seasonal perched water table above fragipan; slope. Severe for CbD: slope.
Moderate permeability.	Poor compaction characteristics.	Slight for CcB. Moderate for CcD; slope.	None to slight for CcB. Moderate for CcD: slope.	Moderate for CcB: slope; moderate permeability. Severe for CcD: slope.
Moderate to rapid permeability; excess seepage.	Fair stability; fair compaction characteristics; fair piping characteristics.	Moderate for CdB, CdD: coarse fragments. Severe for CdE, CdF: slope.	Slight for CdB. Moderate for CdD: slope. Severe for CdE, CdF: slope.	Severe: moderate to rapid permeability; coarse fragments.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—			
	Topsoil	Sand	Gravel	Road fill
*Coulstone: ChB, ChD, ChE, ChF, CvD, CvE, CvF. For Clarksville properties of CvD, CvE, and CvF, see Clarksville series; for Rock land properties of CvD, CvE, and CvF, see Rock land.	Unsuited	Unsuited	Unsuited	Good
Doniphan: DoB, DoD, DoE	Poor: coarse fragments	Unsuited	Unsuited	Fair: moderate shrink-swell potential.
Macedonia: MaB, MaD	Good in surface layer	Unsuited	Unsuited	Fair: moderate shrink-swell potential.
Midco: MdB	Poor: coarse fragments	Fair	Fair	Good
Newark: NeA	Poor: somewhat poorly drained.	Unsuited	Unsuited	Poor: somewhat poorly drained.
Opequon: OpD, OpE, OpF	Unsuitable: thin surface layer; coarse fragments; rockiness.	Unsuited	Unsuited	Unsuited: shallow to bedrock; high shrink-swell potential; rockiness.
Poynor: PyB, PyD, PyE, PyF	Poor: coarse fragments	Unsuited	Unsuited	Fair: moderate shrink-swell potential.
Rock land: RoD, RoE, RoF	Unsuited	Unsuited	Unsuited	Unsuited
Secesh: SeB	Fair: about 8 inches of suitable surface layer.	Unsuited	Fair in substratum.	Good
Viraton: VcB	Fair: thin surface layer.	Unsuited	Unsuited	Fair: moderate shrink-swell potential.
Wilderness: WdB, WdD	Unsuited	Unsuited	Unsuited	Good

interpretations—Continued

Soil features affecting—		Degree and kind of limitation for—		
Ponds		Sanitary landfill (trench type)	Septic tank absorption fields	Sewage lagoons
Reservoir	Embankment			
Moderate to rapid permeability; excess seepage.	Medium to low-compacted permeability.	Moderate for ChB, ChD: coarse fragments. Severe for ChE, ChF: slope.	Slight for ChB. Moderate for ChD: slope. Severe for ChE, ChF: slope.	Severe: moderate to rapid permeability; coarse fragments.
Moderately permeable clay.	Medium to low compacted permeability.	Slight for DoB. Moderate for DoD: slope. Severe for DoE: slope.	None to slight for DoB. Moderate for DoD: slope. Severe for DoE: slope.	Moderate for DoB: moderate permeability; slope. Severe for DoD, DoE: slope.
Moderate permeability	Medium to low compacted permeability.	Slight for MaB. Moderate for MaD: slope.	None to slight for MaB. Moderate for MaD: slope.	Moderate for MaB: slope; moderate permeability. Severe for MaD: slope.
Moderately rapid to rapid permeability; excess seepage.	Excess seepage; difficult to vegetate.	Severe: flooding; permeability.	Severe: flooding; ground water subject to contamination.	Severe: flooding; ground water subject to contamination.
Level or nearly level bottom lands.	Fair to poor compaction characteristics.	Severe: flooding; high water table.	Severe: flooding; high water table.	Severe: flooding; high water table.
Practice not applicable	Practice not applicable	Severe: shallow to bedrock.	Severe: shallow to bedrock.	Severe: shallow to bedrock.
Moderately permeable clay.	Moderate stability and compaction characteristics.	Moderate for PyB. Severe for PyD, PyE, PyF.	Slight for PyB. Moderate for PyD: slope. Severe for PyE, PyF: slope.	Moderate for PyB: slope; moderate permeability. Severe for PyD, PyE, PyF: slope.
Practice not applicable	Practice not applicable	Severe: depth to bedrock; slope.	Severe: depth to bedrock; slope.	Severe: depth to bedrock; slope.
Moderately rapid permeability in lower part of the profile; excess seepage.	Excess seepage	Severe: moderately rapid permeability in lower part of the profile.	Severe: ground water subject to contamination.	Severe: ground water subject to contamination.
Moderate permeability below fragipan.	Moderate compacted permeability.	Severe: cherty fragipan	Severe: slowly permeable, cherty fragipan.	Moderate: moderate permeability below fragipan.
Moderate permeability below fragipan.	Moderate permeability; slight compressibility.	Severe: cherty fragipan	Severe: slowly permeable, cherty fragipan.	Moderate for WdB: moderate permeability below fragipan; coarse fragments; slope. Severe for WdD: slope.

Reaction is the degree of acidity of alkalinity of a soil expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content; that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Engineering interpretations

The 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 the survey area. 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 and special designs.

Soil suitability is rated by the terms good, fair, and poor, which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of the columns in table 8.

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 for preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

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 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.

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 ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate.

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 a depth of 18 inches to 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 also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are 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 its sides, or embankments, are 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, organic matter, and slope, and 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 from the Unified soil classification and the amounts of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Formation and Classification of the Soils

In this section the factors that affect the formation of the soils in the survey area are discussed, the system of soil classification is explained, and the soil series are classified by higher categories. In the section "Descriptions of the Soils," a description of each soil series in the survey area is given.

Factors of Soil Formation

Soils are the product of several processes acting on materials deposited or accumulated by geologic agencies. The factors that determine soil characteristics are (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated, (3) the plant and animal life on and in the soil, (4) the relief, and (5) the length of time the soil material has been subjected to soil-forming activity. These five factors are so closely interrelated that few generalizations can be made about the effect of any one factor unless conditions are specified for the other four.

The parent material affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Climate and plant and animal life, are the active agents that change the parent material to a natural body that has genetically related horizons. The relief of the area in which the soil-forming activity occurs influences the effects of climate and plant and animal life. And time is needed for these elements to change the parent material into soil.

Parent material

The soils in Mark Twain National Forest Area formed in material weathered in place, in loess, or in alluvium or colluvium.

The parent material of the soils that formed in material weathered in place is mainly sedimentary rock from the Ordovician Period and, to a lesser extent, from the Cambrian Period. Soils from material weathered from Jefferson City Dolomite, such as Doniphan soils, have a red clayey subsoil and contain angular and rounded cherty nodules and highly weathered tripolitic chert. The most extensive underlying rock in the area is of the Roubidoux Formation, which consists of an interlayered sequence of dolomite and sandstone. Soils that formed in material from this formation, such as Coulstone soils, are highly leached, very strongly acid, and contain many fragments of chert and sandstone. The Roubidoux Formation is underlain by cherty dolomite of the Gasconade Formation. Soils that formed in material from this formation, such as Clarksville soils, are highly leached, very strongly acid, and generally cherty. Eminence Dolomite is in a few small areas in the northeastern part of the survey area. Soils that formed in this material have a redder, more clayey subsoil than those that formed in material from other formations in the area.

Loess was deposited over the area, probably during the late Pleistocene. Most of the loess has been removed by geologic erosion, but it does remain in gently sloping areas on broad ridgetops. As a consequence, some soils on the uplands formed partly in loess and partly in residuum. Captina, Wilderness, and Macedonia soils are among the soils that formed from these materials.

Soils that formed in colluvium are similar to the soils on surrounding uplands. The colluvium on the stream terraces has been in place long enough for the soils to have moderately developed horizons. On first bottoms, along the drainageways, the soils have been in place only long enough for the formation of weakly developed horizons, if any. Viraton and Claiborne soils formed in colluvium.

The differences in the soils that formed in alluvium are the result of the kind of bedrock underlying the uplands and the general relief of the area. Material weathered from sandstone of the Roudiboux Formation is sandier throughout than that washed from dolomite of the Gasconade and Eminence Formations. Alluvium washed from the highly dissected parts of the area contains a considerable amount of chert and gravel because the material has been washed from the steep drainageways by fast-moving water. Deposits laid down by fast-moving water generally are coarse, and those laid down by slow-moving water are fine. Coarse material is deposited near stream channels or on narrow bottoms where the water flows with the greatest velocity. Fine material is deposited on broader, more nearly level flood plains away from the stream channel. Midco soils formed in coarse material, and Ashton, Secesh, and Newark soils formed in fine material.

Climate

Climate influences both the chemical and physical weathering processes and the biological forces at work in parent material. A major factor in the formation of distinct horizons in a soil is the movement of water down through parent material. The amount of water that percolates through the soils depends on climate factors such as temperature, type and intensity of precipitation, and humidity.

Climate affects soils both indirectly and directly. An indirect effect of climate in the survey area is that it is favorable for the growth of trees, and trees, as well as other plant life, affect the formation of soils differently than climate affects it. A direct effect of climate is that the content of clay in soils tends to increase as precipitation increases and temperature rises. Temperature and precipitation in the area are favorable for the formation of soils that have a thin, light-colored surface layer and a subsoil in which clay has accumulated.

The climate of the area is generally uniform and, as a consequence, the soil characteristics affected by climate generally have developed uniformly.

Plants and animals

The soils of Mark Twain National Forest Area were formed under two types of vegetation. Most of the soils were formed under deciduous trees or a combination of deciduous and coniferous trees. Many of the alluvial soils and the glade soils formed under trees and native grasses.

Large amounts of bases and phosphorus are returned to the soil annually by the shedding of leaves. Generally, deciduous trees return larger amounts of bases and phosphorus to the soil than coniferous trees.

Organic material is added to soils by the decay of leaves, stems, twigs, and roots of plants and trees. This organic matter, in turn, physically and chemically modifies color, structure, and other soil properties. It also creates a favorable environment for biological activity in the soil. Burrowing animals contribute to the forma-

tion of soils by mixing various soil horizons and by bringing fresh material to the surface layer. Earthworms feed on the organic matter and make channels that have the effect of mixing soil material.

Relief

Relief, and factors related to relief, such as drainage, runoff, infiltration, and accelerated erosion, influence the formation of soils. Runoff is more rapid on steep slopes than on more nearly level ones, and steep soils erode faster than more nearly level ones, even if both are of the same material. Steep soils generally are shallow, are cherty, and have little profile development. The more nearly level soils generally are less cherty and have more profile development.

Soils in the survey area are gently sloping to very steep on the uplands and nearly level to gently sloping on the bottom lands. About 44 percent of the acreage on uplands has slopes of 2 to 8 percent, 12 percent has slopes of 8 to 14 percent, 26 percent has slopes of 14 to 35 percent, and 6 percent has slopes of 35 to 60 percent. About 12 percent of the acreage on bottom lands has slopes of 0 to 4 percent.

The elevation in the survey area ranges from about 400 feet near Doniphan to 1,100 feet near Winona. The maximum difference in elevation between the valleys and the adjacent hilltops is about 375 feet.

Time

Time is needed for the factors of climate, plants and animals, and relief to act upon parent material to form a soil. The length of time required for a particular kind of soil to form depends upon the natural forces involved. In the survey area, the young Midco soils formed along the drainageways where alluvium has been in place too briefly for the formation of distinct horizons. The older Clarksville soils formed in residuum, and they have been thoroughly leached of nutrients.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

In classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and forest land; in developing rural areas; in performing 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 classification system used was adopted for general use by the National Cooperative Soil Survey in 1965 (*7*). This system is under continual study. Therefore, readers interested in developments of this system should search the latest literature available (*5*). In table 9, the soil series of the survey area are placed in some categories of the system.

The system of classification has six categores. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. The criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that soils of similar genesis, or origin, are grouped together. The classes of the system applicable to this survey are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different kinds of climate. There are four soil orders in the survey area—Alfisols, Entisols, Inceptisols, and Ultisols.

Alfisols are soils that have a clay-enriched B horizon that has a high base saturation.

Entisols are young mineral soils that do not have genetic horizons or have only the beginnings of such horizons.

Inceptisols are mineral soils in which horizons have definitely started to develop. They generally are on young, but not recent, land surfaces.

Ultisols are soils that have a thoroughly leached subsoil that has a base saturation of less than 35 percent. They commonly occur on old land surfaces.

SUBORDER: Each order has been subdivided into suborders, primarily on the basis of the characteristics that seemed to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of water-logging of soil differences resulting from climate or vegetation.

GREAT GROUPS: Suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that contain a pan that interferes with the growth of roots or the movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9, because it is the last word in the name of the subgroup.

SUBGROUP: Great groups are divided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also have one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the great group.

TABLE 9.—*Classification of the soil series*

Series	Family	Subgroup	Order
Ashton	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Captina	Fine-silty, mixed, mesic	Typic Fragiudults	Ultisols.
Claiborne	Fine-loamy, siliceous, mesic	Typic Paleudults	Ultisols.
Clarksville	Loamy-skeletal, siliceous, mesic	Typic Paleudults	Ultisols.
Coulstone	Loamy-skeletal, siliceous, mesic	Typic Paleudults	Ultisols.
Doniphan	Clayey, mixed, mesic	Typic Paleudults	Ultisols.
Macedonia	Clayey, mixed, mesic	Typic Paleudults	Ultisols.
Midco	Loamy-skeletal, siliceous, mesic	Dystric Eutrochrepts	Inceptisols.
Newark	Fine-silty, mixed, nonacid, mesic	Aeric Fluvaquents	Entisols.
Opequon	Clayey, mixed, mesic	Lithic Hapludalfs	Alfisols.
Poynor	Loamy-skeletal, siliceous, mesic	Typic Paleudults	Ultisols.
Secesh	Fine-loamy, siliceous, mesic	Ultic Hapludalfs	Alfisols.
Viraton	Fine-loamy, siliceous, mesic	Typic Fragiudalfs	Alfisols.
Wilderness	Loamy-skeletal, siliceous, mesic	Typic Fragiudalfs	Alfisols.

FAMILY: Families are separated within 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, thickness of horizons, and consistence.

General Nature of the Area

This section provides information of interest to people who are not familiar with the survey area. Information is given about hydrology; geology, physiography, and drainage; climate; and history.

Hydrology [3]

This section gives a generalized discussion of the importance of water in the survey area. There are, however, significant local exceptions to the conditions described. Nonetheless, it is necessary to have a general knowledge of the hydrology of the area in order to understand water-related problems and the interaction of soil and water.

Common features in the area are losing streams, estavellas, and sinkholes. Numerous stream valleys dissect the area. Most of these valleys have no perennial water, because it is pirated by subsurface solution channels. Water movement in the area is primarily through these solution channels.

The subsurface flow in the area exceeds the annual surface flow. This is a vitally important area for the recharge of springs. Some of the largest springs in the United States are found in, or immediately adjacent to, the Mark Twain National Forest Area.

An indication of the high native quality and beauty of the rivers in the area is the recognition that they have received from the federal government. The Eleven Point River has been designated as a National Scenic River, and a part of the Current and the Jack Fork Rivers is included within the Ozark National Scenic Riverways. Maintaining the high native quality of the water in the area is a major objective of public land management.

After the Eleven Point River had been designated a National Scenic River, the Forest Service began a water-quality monitoring program in the basin. During a 2-year period beginning May 5, 1969, water samples were collected at 16-day intervals at the Eleven Point River near Thomasville, Greer Spring at Greer, Hurricane Creek at the Hurricane Creek Weir, and the Eleven Point River near Bardley.

The data from Greer Spring are typical of large Ozark springs, and the data from the Eleven Point River at Bardley are typical of the major rivers in the survey area. A summary of these data is given in table 10.

The great beauty and clarity of the water in the streams of the survey area largely result from their infertile nature. An examination of the data in table 10 shows that the concentration of nutrients such as nitrates and phosphates in the water is relatively low. The concentration of nitrates appears to be a particularly important factor in the clarity of the stream waters. Investigators have noted in the Eleven Point River basin that a concentration of nitrate greater than about one part per million generally increases the amount of algae growth in the stream and reduces the clarity of the water.

Another important land-management program in the area is the pilot project at the Hurricane Creek barometer watershed. This watershed is one of 23 barometer watersheds in the United States. They serve as pilot project areas for the integration of water management into the overall land management of national forests. The investigations on Hurricane Creek are largely related to ground-water problems in soluble rock terrain.

The Hurricane Creek topographic watershed encompasses 113 square miles. Hurricane Creek, like many of the neighboring streams, is characterized by very little surface flow. Within the Hurricane Creek basin, approximately 85 percent of the average annual runoff is discharged at large springs outside the topographic basin. Extensive ground-water tracing has been done with flourescent dye and is being continued with dye and colored lycopodium spores. Figure 12 shows suc-

[3] By THOMAS J. ALEY, hydrologist, U.S. Forest Service.

TABLE 10.—*Results of water-quality monitoring at*

[Samples collected from

Monitoring sites	Discharge [1]	Water temperature [1]	Turbidity [2]	Specific conductance [1]	Reaction [3]	Dissolved oxygen [1]	Dissolved carbon dioxide [1]	Ammonia [4]	Nitrate nitrogen [4]
Greer Spring:	*Cu. ft. per sec.*	*°F.*	*Jackson candle units*	*Micromhos per cm.*	*pH*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*
Maximum	545	59. 6	21. 00	388	7. 98	10. 73	31. 6	0. 20	0. 78
Minimum	207	58. 4	. 81	184	7. 31	7. 10	6. 0	. 01	. 25
Average	327	59. 2	3. 10	318	7. 53	8. 83	13. 4	. 06	. 46
Eleven Point River near Bardley:									
Maximum	1, 454	73. 6	13. 00	398	8. 49	12. 61	12. 4	. 27	. 56
Minimum	412	48. 4	. 65	283	7. 69	8. 38	1. 7	. 02	. 15
Average	753	60. 8	3. 15	326	8. 01	10. 20	6. 9	. 07	. 32

[1] 46 observations. [2] 41 observations. [3] 43 observations. [4] 33 observations.

cessful ground-water tracing from the Hurricane Creek topographic basin (fig. 12). On six separate occasions water has successfully been traced from the basin of Hurricane Creek, a surface tributary to the Eleven Point River, to Big Spring, a major tributary to the Current River. This means that ground water has moved beneath a major river basin divide.

Movement of ground water in the Hurricane Creek area typically is rapid. Table 11 summarizes the travel distances and velocities encountered in the ground-water tracing in the Hurricane Creek basin. The evidence collected to date indicates a well-integrated ground-water net.

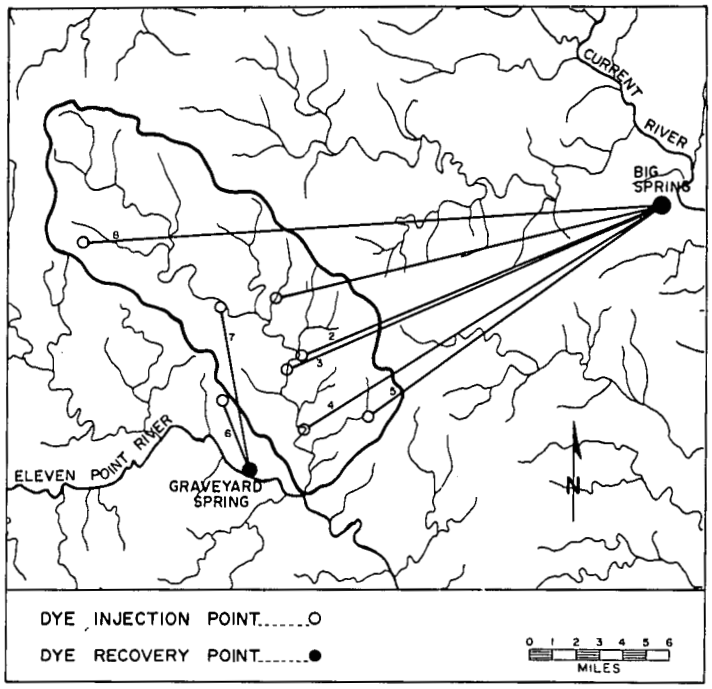

***Figure 12.*—Subsurface flow routes established by water tracing in the Hurricane Creek basin. Straight lines extend from the point of dye injection to the point of recovery. The map shows the topographic basin of Hurricane Creek. Surface and subsurface basins are shown. The numbers in this figure correspond with the case numbers used in table 11.**

The soluble rock terrain of the survey area presents some water-related problems that are not common in other types of terrain. As a result of work on the Hurricane Creek barometer watershed, four general water-related problems have been identified that are applicable to the Mark Twain National Forest Area, as well as to many other soluble rock terrains. These problems are discussed in the following paragraphs.

Water availability problems are common because of the high degree of localization of ground-water flows. The amount of water produced by wells varies widely, and "dry holes" are common. Adequate water supplies, either surface or subsurface, generally are difficult to obtain.

Ground-water supplies can be contaminated easily. Long-distance underground transport, rapid subsurface flow, and inadequate filtering can cause severe and widespread pollution problems. It is not necessary for pollution sources to be large to cause significant health hazards. Ground-water contaminants in a region of soluble rock typically move as "slugs" in much the same way as contaminants move in surface streams. The protection of water quality in areas of soluble rock requires continuous vigilance. Unsound management practices can do more damage to ground water in a region of soluble rock than in any other type of terrain.

Materials than can contaminate ground-water supplies in the survey area include sewage from poorly located septic fields and lagoons, animal wastes from feedlots and similar operations, materials from improperly located dumps, viruses from dead or diseased animals, and chemicals either from spills, careless or improper usage, or farming or forestry activities.

Land use can alter water quality and water quantity. In areas of soluble rock, where there are well-developed

Greer Spring and at the Eleven Point River near Bardley

May 1969 to May 1971]

Total nitrogen[4]	Ortho-phosphate [5]	Total phosphate [4]	Fetal coliform [6]	Bicarbonate alkalinity [1]	Calcium [4]	Magne-sium [4]	Potassi-um [7]	Chloride [4]	Sulfate [5]	Total iron [5]
Mg. per l.	*Mg. per l.*	*Mg. per l.*	*Colonies per 100 ml.*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*	*Mg. per l.*
0. 85	0. 06	0. 09	173	208. 6	41. 0	27. 0	1. 08	2. 25	94. 00	360
. 29	. 02	. 03	1	138. 9	24. 6	13. 5	. 93	. 39	. 30	30
. 57	. 03	. 06	27	178. 9	35. 1	21. 7	1. 00	1. 36	21. 58	127
. 69	. 05	. 09	452	250. 0	41. 2	28. 0	. 99	2. 70	17. 60	440
. 18	. 00	. 01	1	130. 5	28. 8	16. 8	. 80	. 39	. 50	10
. 44	. 02	. 04	38	186. 4	35. 7	21. 7	. 92	1. 29	4. 49	138

[5] 32 observations. [6] 44 observations. [7] 6 observations.

subsurface flow routes, the use of the land can alter the ratio of surface to subsurface flow. Both farm and forestry activities are capable of changing the ratio of surface to subsurface flow. On one hand this can increase the hazard of flooding, and on the other it can cause small, esthetically appealing streams to become dry. It can also change the flow of springs important for water supplies.

The survey area is subject to unique hazards of flooding that must be understood if the land is to be well managed. Standard equations and curves used in projecting floods in the regions of nonsoluble rock are often grossly in error when applied to regions of soluble rock.

Floodwater retention dams in regions of soluble rock often serve as gigantic ground-water spreading basins. Through the introduction of poor-quality water underground, these dams lead to the contamination of ground-water supplies.

Collapse or subsidence of the land surface in regions of soluble rock can be induced by changes in the water regimens. Both increases and decreases of ground-water levels can induce collapse or subsidence and endanger life and property.

The delineation of a watershed, the area tributary to a given point, is generally the first step in planned water management. In regions of soluble rock, the area tributary to a given point may differ greatly from the topographic watershed. On Hurricane Creek, parts of the basin are tributary to the Eleven Point River and other parts are tributary to the Current River. It is necessary to have a good general picture of the drainage area before beginning work to increase water production, to improve flood protection, or to maintain or improve water quality.

Soils influence the rate at which water moves into the residuum and underlying bedrock. The rate, in conjunction with the depth of the soil, is important in relating surface and subsurface flows. This information is essential to watershed planning that involves flood hazards, erosion hazards, and the character and amount of surface and subsurface flow.

TABLE 11.—*Water volumn, straight-line travel distances, and average velocities of eight ground-water tracings from the Hurricane Creek topographic basin*

Case number and subsurface flow route [1]	Water volume		Straight-line distance	Approximate average straight-line velocity
	Injection site	Recovery site		
	Cu. ft. per sec.	*Cu. ft. per sec.*	*Miles*	*Ft. per hour*
1. Wildcat Hollow to Big Spring	0. 3	430	17. 0	310
2. Blowing Spring estavella to Big Spring	. 3	415	17. 5	390
3. Leslie Spring Swallet to Big Spring	. 7	430	17. 8	350
4. Johnson Spring Swallet to Big Spring	1. 5	370	18. 0	130
5. Goldmine Hollow to Big Spring	. 5	660	15. 0	330
6. Davis Lake to Graveyard Spring	. 1	30	3. 5	150
7. Hurricane Creek to Graveyard Spring	. 2	30	7. 5	20
8. Dowler Sink to Big Spring	2. 5	587	25. 3	660

[1] Case numbers correspond to numbers shown in figure 12.

The soils of the area have been placed in four hydrologic groups (*8*). These groups indicate runoff potential. They are based on the intake of water at the end of long-duration storms, intake after prior wetting of the soils, and intake after the soils have had an opportunity to swell. These groupings are made without consideration to slope, the protective effects of vegetation, or the local nature of the bedrock.

Group A.—Soils that have a high infiltration rate. This group consists mainly of well-drained and excessively drained, sandy or gravelly soils. These soils have a high rate of water transmission and a low runoff potential.

Group B.—Soils that have a moderate infiltration rate. This group consists mainly of moderately well drained soils that are moderately fine textured to moderately coarse textured. These soils have a moderate rate of water transmission.

Group C.—Soils that have a slow infiltration rate or soils that have layers that impede the downward movement of water. This group consists of moderately fine textured or fine textured soils. These soils have a slow rate of water transmission.

Group D.—Soils that have a very slow infiltration rate. This group consists mainly of (1) clay soils that have a high shrink-swell potential; (2) soils that have a permanent high water table; (3) soils that have a claypan or clay layer at or near the surface; and (4) shallow soils underlain by nearly impervious substrata. These soils have a very slow rate of water transmission.

In table 12 each soil series in the survey area is classified by hydrologic group.

TABLE 12.—*Water-management characteristics of the soils*

Soil	Hydrologic group	Drainage
Alluvial land	A	Variable.
Ashton	B	Well drained.
Captina	C	Moderately well drained.
Claiborne	B	Well drained.
Clarksville	B	Somewhat excessively drained.
Coulstone	B	Somewhat excessively drained.
Doniphan	B	Well drained.
Macedonia	B	Well drained.
Midco	A	Somewhat excessively drained.
Newark	C	Somewhat poorly drained.
Opequon	D	Well drained.
Poynor	B	Well drained.
Rock land	D	Well drained.
Secesh	B	Well drained.
Viraton	C	Moderately well drained.
Wilderness	C	Moderately well drained.

Geology, Physiography, and Drainage [4]

The survey area is part of the Salem Plateau, which covers the south-central part of Missouri and extends southward into Arkansas (*2*). The Salem Plateau is a major subprovince of the Ozarks and represents a landform developed by prolonged weathering of moderately soluble carbonate (dolomite) bedrock. The bedrock underlying the survey area ranges in age from the Cambrian to the Pennsylvanian.

From the oldest to the youngest, the geologic formations in the survey area are the Eminence, Gasconade, Roubidoux, and the Jefferson City Formations (fig. 13). The role of these formations in the development of soils is discussed in the section "Formation and Classification of the Soils."

The Eminence Formation is in only a few small areas along the Current River in the eastern part of the survey area. This formation consists of massive, fine-grained to medium-grained dolomite. It is light gray and essentially free of chert. In places it varies abruptly in thickness because its weathered surface is somewhat pinnacled. Generally, it is 300 feet thick.

The Gasconade Formation is divided into several units. The lowest of these is referred to as the Gunter Sandstone. It is thin, sandy dolomite 10 to 20 feet thick. The Gunter is overlain by the lower Gasconade, a relatively light, thin-bedded to medium-bedded dolomite that has a few caves. Chert is on weathered slopes of the lower Gasconade as an extensive blanket of small, angular, light-gray fragments that sometimes are referred to as snowy chert. The lower Gasconade is capped by an extensive, massive chert reef called the Cryptozoon Reef. This reef is 8 to 10 feet thick and consists of hard, brittle, intensely fractured chert. The upper Gasconade is a massive, thick dolomite that has large caves. In the upper Gasconade steep slopes and bluffs have formed along stream valleys. The Gasconade Formation generally ranges from 300 to 400 feet in thickness.

The Roubidoux Formation consists of an interlayed sequence of sandstone, medium to massive beds of sandy dolomite, and dolomite. Generally, there is a massive middle unit of sandstone. Cherty dolomite and cherty sandstone lie above and below the middle unit. In the southern part of the survey area the Roubidoux Formation consists mostly of dolomite. The Roubidoux has undergone such intensive weathering that much of it remains only as insoluble chert and sandstone boulders. The Roubidoux ranges from 150 to 200 feet in thickness.

The Jefferson City Formation is a medium-bedded sequence of dolomite that is only in the southern part of the survey area. A moderate amount of chert is present as nodules in the weathered remains of the Jefferson City-Roubidoux contact. The thickness of the Jefferson City and related dolomite is more than 400 feet. However, only the lower 100 feet or less is present in the southern part of the survey area.

Most of the area is mantled by residuum that is more than 100 feet thick in the area of Winona. During well-drilling operations residuum has been encountered locally at a depth of more than 200 feet. The residuum derived from the weathering of the underlying bedrock is clay or cherty clay. Solution of the original calcium and magnesium carbonate bedrock has removed material and left a mass of permeable, relatively insoluble sand, chert, and red clay.

[4] JAMES H. WILLIAMS, geologist, Missouri Geological Survey and Water Resources, helped to prepare this section.

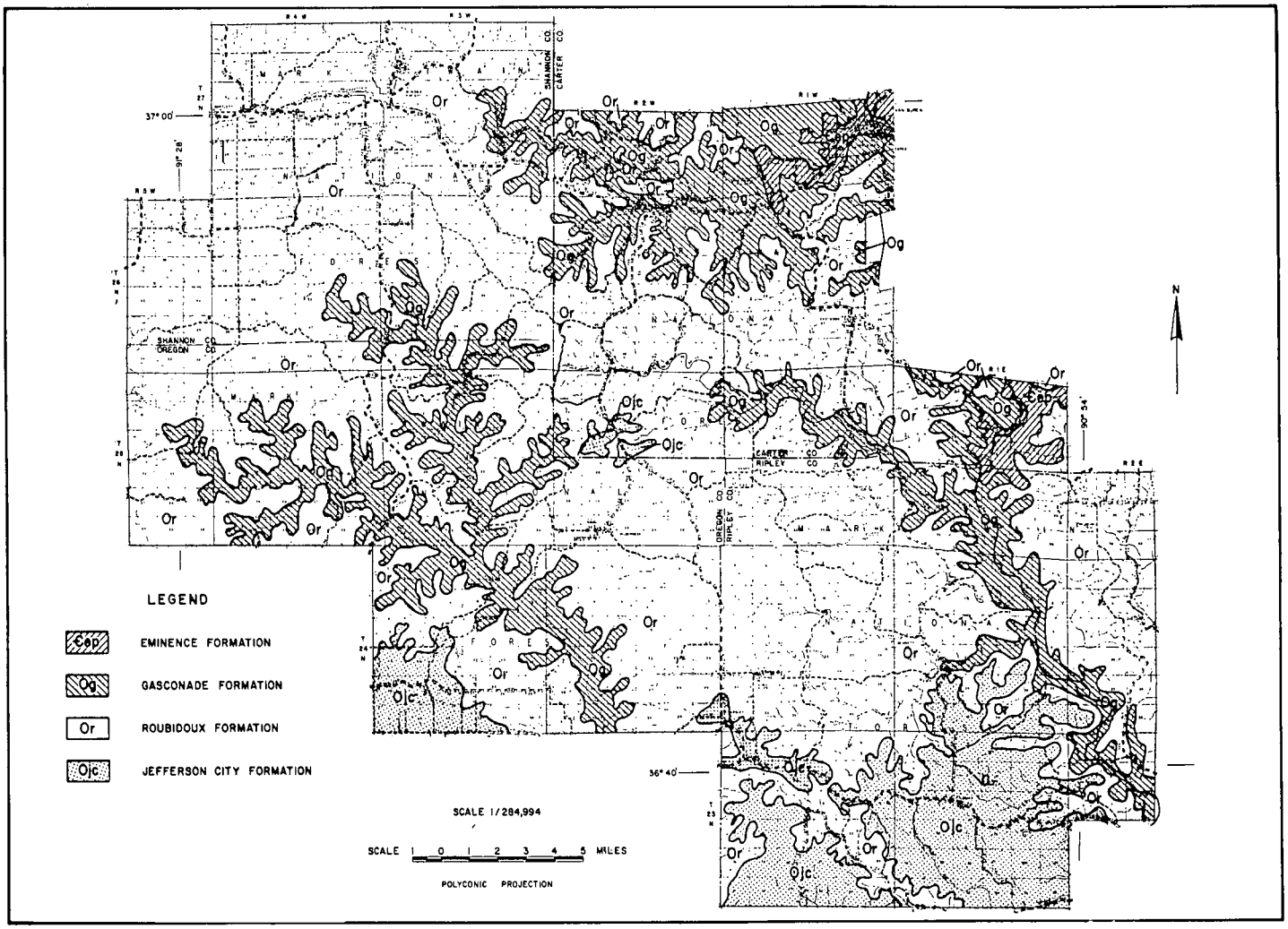

Figure 13.—Geologic map of the survey area.

The drainage of the area is generally to the south. The soils surrounding the Eleven Point and Current Rivers are generally steep and cherty (fig. 14).

Climate [5]

The Mark Twain National Forest Area has a continental climate characterized by frequent and sometimes extreme changes in weather. The summers can be hot and humid, and the winters have periods of raw, severe weather.

The temperature and precipitation data given in table 13 are compiled from the National Weather Service's cooperative stations at Doniphan and Van Buren. The combined data from these two stations are representative of the climate in the survey area. The period covered by the data is 30 years.

The temperature exceeds 100° F. in 7 out of 10 years, and once 100° is reached, it generally occurs on 3 consecutive days. In 6 out of 10 years, the temperature drops below zero. This condition seldom lasts more than a few days. There have been times, however, when the temperature has fallen below zero for 5 consecutive days or more.

Precipitation, which is uniform throughout the year, averages more than 45.5 inches. The rain is mostly the result of thunderstorm activity, which is at a maximum in spring and at a minimum in fall. Thus, May is the wettest month, averaging more than 5 inches, and October is the driest month, averaging only 2.5 inches. Monthly extremes have ranged from a trace in June 1952 to more than 13 inches in January 1950.

The average length of the growing season is about 175 days. In an area that has such diverse terrain, nighttime temperatures can vary considerably from one location to another. During periods of light winds, when radiation freezes often occur, temperatures observed in valleys can be several degrees colder than those observed along ridges or on level ground. Table 14 shows the last date in spring and the first date in fall when

[5] By Warren M. Wisner, climatologist for Missouri, National Weather Service, U.S. Department of Commerce.

TABLE 13.—*Temperature and*

Month	Temperature				
	Average daily			Two years in 10 will have at least 4 days with—	
	Maximum	Minimum	Mean	Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—
	° F.	° F.	° F.	° F.	° F.
January	47. 7	21. 8	34. 8	66	6
February	51. 8	24. 8	38. 3	70	10
March	59. 7	31. 5	45. 6	78	15
April	72. 6	44. 1	58. 4	86	29
May	81. 2	52. 5	66. 9	91	38
June	88. 4	61. 3	74. 9	97	50
July	92. 1	66. 1	79. 1	101	57
August	91. 2	63. 4	77. 3	100	53
September	84. 0	54. 8	69. 4	96	41
October	74. 5	41. 7	58. 1	87	28
November	60. 8	30. 8	45. 8	76	15
December	49. 5	24. 6	37. 1	67	10
Year	71. 1	43. 1	57. 1	101	6

[1] Less than 0.05 inches.

freezing temperatures might be expected. This table is based on instrument readings taken 5 feet above ground level. Frost may occur in sheltered locations when the temperature at the observation level is above freezing.

Snowfall averages less than 7 inches a year. It usually falls only three or four times a season, and then it quickly melts. In 1960, 29 inches of snow fell, while in 1953 only a trace was reported.

Violent storms often result from the clash between the warm, humid airmass from the Gulf of Mexico and the cooler continental airmass. However, since 1915 only five tornadoes have been reported within the survey area. Damage caused by hail, lightning, or strong winds has occurred almost every year in some part of the area. The greatest threat of severe weather is during spring.

TABLE 14.—*Probabilities of last freezing temperatures in spring and first in fall*

Probability	Dates for given probability and temperature				
	32° F. or lower	28° F. or lower	24° F. or lower	20° F. or lower	16° F. or lower
Spring:					
1 year in 10 later than	May 8	April 20	April 13	April 7	March 31
2 years in 10 later than	May 3	April 16	April 8	March 31	March 23
5 years in 10 later than	April 24	April 9	March 30	March 19	March 6
Fall:					
1 year in 10 earlier than	September 30	October 15	October 25	October 28	November 2
2 years in 10 earlier than	October 4	October 19	October 28	November 1	November 8
5 years in 10 earlier than	October 13	October 26	November 3	November 9	November 20

precipitation

Temperature—Continued		Precipitation					
Extreme values—		One year in 10 will have—				Snowfall	
Maximum	Minimum	Average total	Less than—	More than—	Greatest daily rainfall	Average	Greatest monthly amount
° *F.*	° *F.*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
77	−14	3. 70	0. 79	6. 58	4. 45	1. 8	6. 8
88	−21	3. 57	1. 88	5. 64	3. 05	2. 2	10. 8
92	−3	4. 54	2. 14	6. 96	4. 65	1. 4	16. 5
92	18	4. 31	1. 85	7. 13	2. 71	(1)	(1)
97	29	5. 29	2. 78	8. 78	3. 57	0	0
108	40	3. 97	1. 40	5. 64	4. 35	0	0
110	47	3. 97	1. 48	6. 10	4. 72	0	0
109	42	3. 10	1. 24	5. 52	3. 45	0	0
106	29	3. 81	. 76	6. 88	3. 10	0	0
96	15	2. 57	. 17	4. 38	3. 70	0	0
85	5	3. 58	1. 20	5. 99	3. 13	. 3	3. 0
78	−6	3. 29	. 97	6. 17	2. 86	1. 3	11. 0
110	−21	45. 70	36. 41	54. 60	4. 72	6. 9	16. 5

History

The Mark Twain National Forest Area is composed of steep hills, swiftly flowing streams, and rugged forests of great scenic beauty. The first known inhabitants were the Osage and Quapaw Indians. Archeological evidence indicates the area had been occupied by Indians for several thousand years (*3*). Artifacts are still found commonly around springs, under overhanging ledges, and on stream terraces.

In the early 1800's the area was thinly settled by people migrating from Tennessee and Kentucky. These people took up residence along the streams and near springs in much the same manner as did the Indians before them. The alluvial and colluvial soils were cleared for growing food and a limited amount of forage and grain for livestock (fig. 15).

After the Civil War, logging of the virgin shortleaf pine and hardwood forests began. This activity peaked about 1900. It was a period of exploitation of natural resources. Timber was logged off without regard to future regeneration and was replaced by less valuable and less desirable species. The closing of the sawmills forced the workers to engage in the marginal farming of the steep slopes. This farming greatly intensified the hazard of erosion and stream sedimentation. Wildlife also suffered as a result of these practices. The White-tailed deer and the wild turkey were almost extinct in the area by that time.

In the 1930's the Federal Government began buying land in the area and initiated a program of rehabilitation and forest management. Today, although many of the scars remain, most of the wildlife populations have increased, the streams have cleared, and the forests are once again productive.

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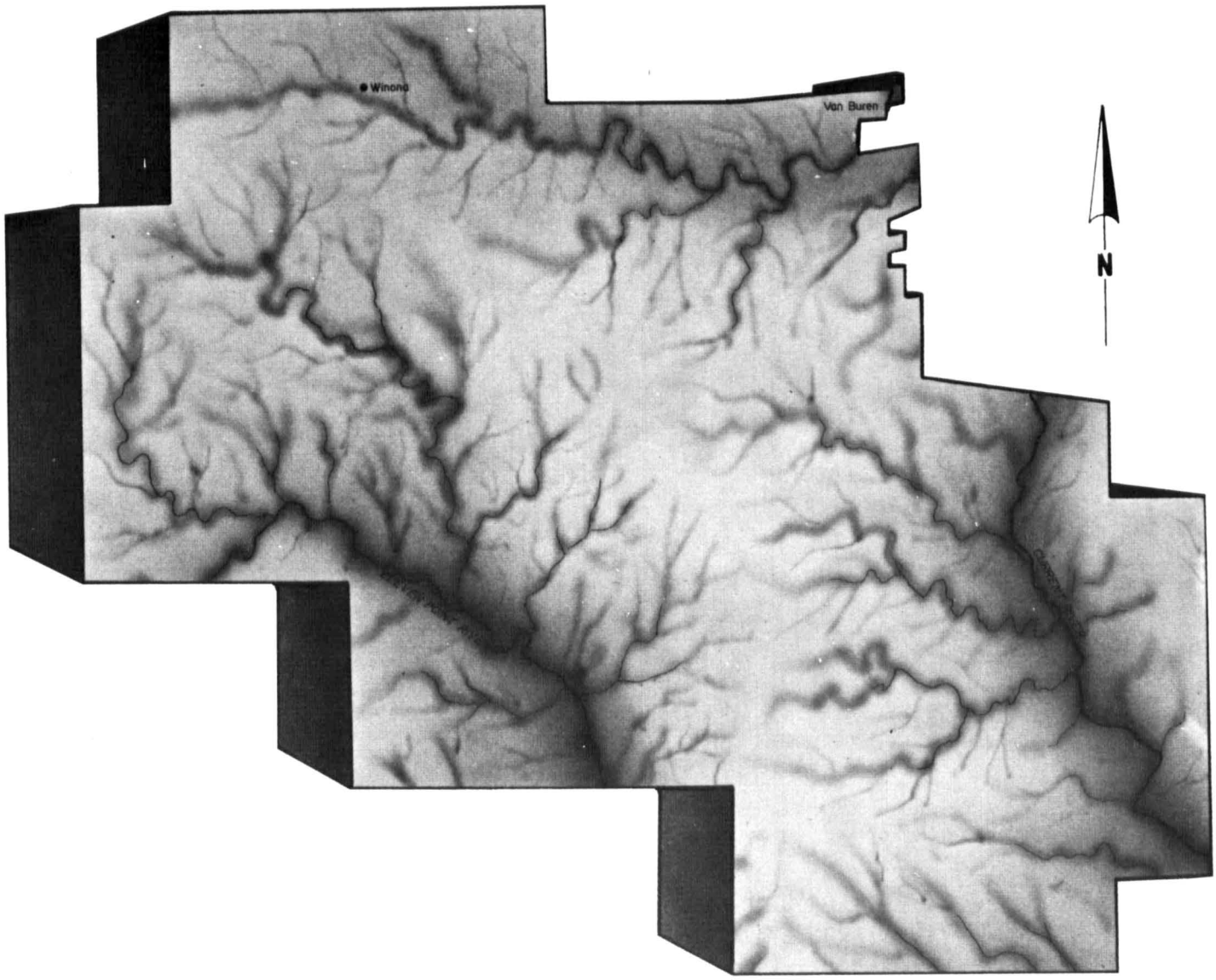

Figure 14.—Relief and drainage patterns of the survey area.

Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

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 clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Estavella. A physiographic feature which, depending on hydrologic conditions, can serve either as a swallowhole, swallowing an entire spring, or as a resurgence, discharging water after a major storm.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Fragipan. A loamy, brittle, subsurface horizon that is very low in organic-matter content and clay but is rich in silt or very fine sand. The layer is seemingly cemented. When dry, it is hard or very hard and has a high bulk density in comparison with the horizon or horizons above it. When moist, the fragipan tends to rupture suddenly if pressure is applied, rather than to deform slowly. The layer is generally mottled, is slowly or very slowly permeable to water, and has few or many bleached fracture planes that form polygons. Fragipans are a few inches to several feet thick; they generally occur below the B horizon, 15 to 40 inches below the surface.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Karst topography. Topography of the type found in the Karst, a limestone plateau on the eastern coast of the Adriatic. It is marked by sinkholes, interspersed with abrupt ridges and irregular protuberant rocks, and by caverns and underground streams.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Losing stream. A surface stream channel which, because of cavernous or otherwise porous bedrock or other material beneath it, transmits most or all of its flow through the channel bottom into the underground water supply. In this area, the term is commonly applied to those stream channels that are underlain by cavernous or highly weathered dolomite or limestone bedrock into which water enters through discrete and continuous cracks, crevices, caves, and tunnels and flows at times for as far as 30 miles before reemerging onto the earth's surface.

Microclimate. Local climatic conditions, brought about by the changes in the general climate resulting from local differences in elevation and exposure.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH value. A numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Residuum. Unconsolidated, partly weathered mineral material that accumulates over disintegrating solid rock. Residual material is not soil but is frequently the material in which a soil has formed.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Sinkhole. A vertical hole worn by water into limestone rock along a joint, or fracture. Such a hole usually is connected with an underground channel. The caving in of the roof may cause more depression and the formation of a pond.

Slope. Classes of slope used in this survey are:

Nearly level	0 to 2 percent
Gently sloping	2 to 8 percent
Moderately steep	8 to 14 percent
Steep	14 to 35 percent
Very steep	35 to 60 percent

Soil depth. Classes of soil depth used in this survey are:

Very shallow	Less than 10 inches
Shallow	10 to 20 inches
Moderately deep	20 to 36 inches
Deep	Over 36 inches

Figure 15.—Fence of chert and stone cleared from the field.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Solution channel. Discrete and continuous cracks, crevices, caves, and tunnels formed by the dissolving action of carbon dioxide and organic acid-laden water as it percolates through soluble carbonate limestone and dolomite bedrock.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Swallet. A point where a surface stream is engulfed in the ground, not necessarily into an accessible opening.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

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 loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

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