Series 1957, No. 19 Issued September 1964

SOIL SURVEY
Washington County, Nebraska

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
in cooperation with the
UNIVERSITY OF NEBRASKA
Conservation and Survey Division

HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of Washington County, Nebr., will serve several groups of readers. It will help farmers in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, ponds, and other structures; aid foresters in managing woodlands; and add to our knowledge of soil science.

Locating soils

Use the index to map sheets at the back of this report to locate areas on the large map. The index is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located. When the correct sheet of the large map has been found, it will be seen that boundaries of the soils are outlined, and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they occur on the map. The symbol is inside the area if there is enough room; otherwise, it is outside the area and a pointer shows where the symbol belongs.

Finding information

This report contains sections that will interest different groups of readers, as well as some sections that may be of interest to all.

Farmers and those who work with farmers can learn about the soils in the section "Descriptions of the Soils" and then turn to the section "Use and Management of Soils." In this way, they first identify the soils on their farm and then learn how these soils can be managed and what yields can be expected. The "Guide to Mapping Units and Capability Units" at the back of the report will simplify use of the map and report. This guide lists each soil and land type mapped in the county, and the page where each is described. It also lists, for each soil and land type, the capability unit and the page where it is described.

Foresters and others interested in woodlands can refer to the section "Use of Soils for Woodland." In that section the soils in the county are grouped according to their suitability for woodland sites, and some factors affecting management are explained.

Engineers and builders will want to refer to the section "Engineering Uses of Soils." Tables in that section show characteristics of the soils that affect engineering.

Scientists and others who are interested will find information about how the soils were formed and how they were classified in the section "Genesis, Classification, and Morphology of Soils."

Students, teachers, and other users will find information about soils and their management in various parts of the report, depending on their particular interest.

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

* * * * *

This soil survey was started by the Soil Conservation Service in the fall of 1938. It was all completed in the fall of 1940, except for the survey of the Missouri River bottom lands. The University of Nebraska Conservation and Survey Division completed the survey of the Missouri River bottom lands in the summer of 1941. In the 10 years that followed, the river bottom lands in the county were flooded annually to some extent. In 1952 the entire bottom lands were flooded. Because of the flooding, the bottom lands of the county were resurveyed in the spring of 1957 by the Soil Conservation Service. Unless otherwise indicated, all statements in the report refer to conditions in the county in 1957. The soil survey of Washington County was made as part of the technical assistance furnished by the Soil Conservation Service to the Papio Soil and Water Conservation District.

Cover picture.—Terracing on a field of alfalfa and brome.

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SOIL SURVEY OF WASHINGTON COUNTY, NEBRASKA

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WASHINGTON COUNTY, located in east-central Nebraska (fig. 1), has a land area of 387 square miles, or 247,680 acres. The Missouri River, which is the Nebraska-Iowa boundary, is also the east boundary of the county. Blair, the county seat and largest town, is on the Missouri River. Physiographically, the county consists of the Missouri River bottom lands along the east side, the steep to rolling loessal uplands in the center, and the Elkhorn River bottom lands along the southwest side.

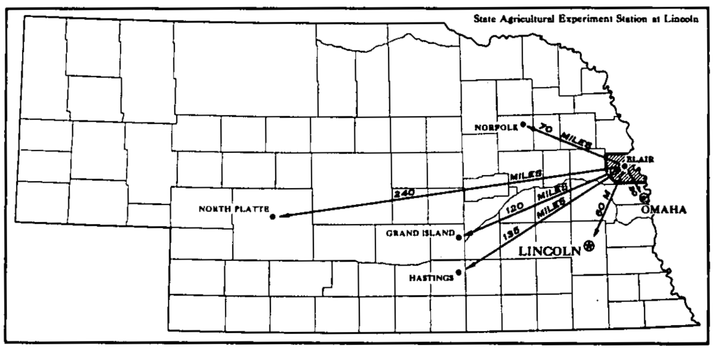

Figure 1.—Location of Washington County in Nebraska.

Almost all of the county is agricultural, and most of the land is in farms. About 90 percent is in cropland, 5 percent is in grass, and 5 percent is in woodland. Corn, small grain, alfalfa, and soybeans are the main crops. Grain and livestock production are the most important farm enterprises. Much of the grain is fed to livestock.

The Papio Soil and Water Conservation District, the first in Nebraska, was organized in Washington County in the spring of 1938. It was named for Papillion Creek (often called Papio Creek) that rises in the north-central part of the county. Personnel of the Soil Conservation Service were assigned to assist the District in the summer of 1938.

How Soils Are Named, Mapped, and Classified

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

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and kind of streams; kinds of native plants or crops; kinds of parent material; and many facts about the soils. They dug or bored many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down to the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to uniform procedures.

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. Luton and Monona, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in natural characteristics.

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

Some soil types vary in slope, degree of erosion, or some other feature affecting their use. Practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Monona silt loam, 3 to 7 percent slopes, is one of several phases of Monona silt loam, a soil type that ranges from nearly level to moderately sloping.

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

In some places, different kinds of soils are so intricately associated and so small in size that it is not practical to show them separately on the map. Therefore, the soil scientists show this association of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex, is named for the major soil series in it, for example, Lamoure-Colo silty clay loams. Also, in most mapping, there are areas to be shown that are so shallow, or so frequently worked by wind and water that they cannot be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Gullied land, Judson materials, or Riverwash, and are called land types rather than soils.

If two or more soils that normally do not occur in regular geographic association are so intricately mixed that separate mapping is impractical, the soils are mapped as an undifferentiated mapping unit. The unit is named for the soils in it. An example in Washington County is Moody and Marshall soils, 3 to 7 percent slopes.

Only part of the soil survey was done when the soil scientists had named and described the soil series and mapping units, and had shown the location of the mapping units on the soil map. The mass of detailed information they had recorded then needed to be presented in different ways for different groups of users, among them farmers, managers of woodlands and rangelands, and engineers.

To do this efficiently, the soil scientists consulted with persons in other fields of work and jointly prepared with them groupings that would be of practical value to different users. Such groupings are the capability classes, subclasses, and units, designed primarily for those interested in producing the short-lived crops and tame pasture; range sites, for those using large tracts of native grass; tree planting sites, for those interested in establishing windbreaks; and the classifications used by engineers who build highways or structures to conserve soil and water.

General Soil Map

After studying the soils in a locality and the way they are arranged, it is possible to make a general map that shows the main patterns of soils. Such a map is the colored general soil map in the back of this report. These patterns are called soil associations. Each kind of association, as a rule, contains a few major soils and several minor soils in a pattern that is characteristic, although not strictly uniform.

The soils within any one association are likely to differ greatly among themselves in some properties; for example, slope, depth, stoniness, or natural drainage. Thus, the general map does not show the kind of soil at any particular place. It does, however, show main patterns of soils. Each pattern may contain several kinds of different soils.

Each soil association is named for the major soil series in it, but, as already noted, soils of other series may also be present. The major soil series of one association may also be present in other areas but in a different pattern.

The general soil map is useful to people who want a general idea of the soils, who want to compare different parts of a county, or who want to know the possible location of good-sized areas suitable for a certain kind of farming or other land use.

1. Cass-Leshara association: Sandy to silty soils of the bottom lands of the Elkhorn River.

This association is in the bottom lands of the Elkhorn River, along the southwestern edge of the county. It makes up about 2 percent of the county. The level soils along the stream have developed in water-deposited material, or alluvium, and the soils along the gentle slopes into the valley have developed in slope wash, or alluvium and colluvium. Most of the soils in this association are nearly level; however, those next to the stream channel and along the entrenched drainageways are on short, steep slopes.

The Cass, Leshara, and Judson soils are dominant in this association. Minor soils are the Lamoure, McPaul, Sarpy, Rauville, and a few others. The soils of this association are mostly noncalcareous to a depth of 3 feet or more.

The Leshara and Judson are deep, dark silty soils that are commonly stratified. The Leshara soils are on imperfectly drained bottom lands. The Judson and McPaul soils are on better drained areas near the outer edge of the valley. The Cass soils are the most extensive in this association and occur with the Leshara soils. They have a dark, thick, loamy to sandy surface layer over a moderately sandy subsoil. The Sarpy soils are along the river channel and have a loamy to very sandy surface layer and a sandy subsoil.

The poorly drained, frequently flooded lowlands that are along the channel are not suitable for cultivation. They are loamy to clayey and are included with the Rauville soils. There are a few acres of alkali soils south of Arlington, across the Elkhorn River in the southwestern part of the county. More of those soils are in Dodge County to the south and west.

Most soils in this association are cultivated. They respond well to fertilizer and under good management produce high yields of corn, soybeans, sorghum, and alfalfa. Water management, which includes protection of the land from overflow and stabilization of the water table, is the main problem. In dry periods this excess water may be beneficial to crops. Water for irrigation is available in the alluvial gravel under the soils in this association and is used to stabilize production of nursery crops and other crops that have a high value per acre.

Farms that are on predominantly deep, level soils are of the cash-grain type; those that include wet or rough land are of the grain-livestock type. Roads parallel the river between farmsteads; they follow section lines in only a few places.

2. Moody-Belfore association: Clayey to silty soils of the rolling loess uplands west of Bell Creek.

The soils in this association make up about 17 percent of the county. They are along the west side of the county, west of Bell Creek. They have developed in loess in the uplands and on the Bell Creek terrace. The soils along the lower slopes and upland drainageways have developed in the alluvial and colluvial material brought down from the uplands.

The major soils in this association are the Belfore, Moody, and Judson. The Luton, Nora, Crofton, and Sharpsburg are important soils in the area where they occur.

The Belfore soils are deep, dark, moderately fine textured soils on the nearly level ridgetops. The surface layer is a dark, granular silty clay loam over a somewhat browner, finer textured, subangular blocky subsoil. The Belfore soils are noncalcareous to a depth below 5 feet.

The Moody soils are on gently rolling to rolling slopes that are no more than moderately eroded. They are similar to the Belfore soils but have less clay in the subsoil and are calcareous higher in the profile.

The deep, dark silty Judson soils are around the heads of drainageways and on the lower slopes.

The Nora are the dominant soils on the rolling to steep slopes that are moderately to severely eroded. They are lighter colored and less clayey than the Moody soils, and lime is usually within 18 inches of the surface.

The silty, calcareous Crofton soils are in the areas that slope into the Elkhorn River bottom and on the severely eroded points and banks along drainageways throughout the uplands. They have a thin, dark surface layer where they have remained in grass or trees. In cultivated areas the dark surface layer has usually been removed.

The deep, dark, moderately fine textured Lamoure and Colo soils are along the drainageways of the nearly level uplands. The Sharpsburg soils are on the terraces along Bell Creek. These soils, in color and structure, are similar to the Belfore but are less clayey throughout the profile. The deep, dark clayey soils of the Luton series are on the bottom lands along Bell Creek. In places they are calcareous and slowly permeable.

Most of this association is cultivated, and yields of all the crops commonly grown in the area are good. In years of subnormal rainfall, a small acreage of nursery crops on the Bell Creek terrace is irrigated.

Occasional flooding and slow permeability are problems on the Luton soils along Bell Creek. Runoff and erosion are the major problems on the rolling uplands where the Moody and Nora soils occur. Water conservation in dry periods and water disposal in periods of excess moisture are the major problems on the Belfore soils.

Most farms in this area are of the cash-grain type: some are of the livestock type. Good gravel roads are on most section lines.

3. Sharpsburg-Marshall association: Silty to clayey soils of the nearly level to rolling loess uplands east of Bell Creek.

This association is in the center of the county east of Bell Creek; it includes the Papillion Creek drainage area, as well as a narrow band of sloping land that drains toward the Elkhorn River and Bell Creek. It makes up about 35 percent of the county.

The soils have developed in loess on the nearly level uplands and upland slopes. Along the lower slopes and along the drainageways from the uplands, the soils have developed in alluvial-colluvial deposits brought down from the slopes.

The main soils are the Sharpsburg of the nearly level uplands, the Sharpsburg and Marshall soils on the gently rolling to rolling slopes, and the Nora soils of the steep or eroded slopes of the uplands. These soils have developed in loess. Other soils included are the Crofton on the steep, severely eroded points and shoulders of slopes, the Judson on the lower slopes and along small upland drainageways, and the Lamoure and Colo along larger drainageways. Figure 2 shows the pattern of the soils in the Sharpsburg-Marshall association.

The Sharpsburg soils are deep, dark, moderately fine textured soils. They are well drained and noncalcareous. The Sharpsburg and Marshall soils have similar profiles. The Nora soils have lime within 2 feet of the surface and have lost much of the surface soil.

Small, scattered areas of Crofton soils occur on the steepest slopes. Their dark surface layer is thin or absent, and lime is usually at or near the surface. The nearly level to gently sloping Judson soils are deep, dark, and medium to moderately fine textured. They show little profile development and have little or no lime within the profile. The Lamoure and Colo are alluvial soils along the larger streams. They are deep, dark, and nearly level. They have a moderately fine textured subsoil that commonly is finer textured with depth. In some areas lime is present in the subsoil and substratum.

Most of this association is cultivated, and the areas on nearly level to moderate slopes are among the most productive in the county. Most farms are of the cash-grain type; some are of the livestock type. Good gravel roads are on most section lines.

4. Monona-Crofton association: Silty soils of the rolling hills and bluffs west of the Missouri River bottom lands.

This association consists of deep silty soils that have developed in loess on the eastern edge of the uplands. About 30 percent of the county is in this association. This association comprises a rolling to hilly area that is dissected by numerous streams that drain to the east into the Missouri River (fig. 3). The streams in this area have a grade that is much steeper than that of the streams in other areas of the uplands. All start at about the same elevation in the uplands; those in this part of the county empty in the Missouri River in 10 to 15 miles, and those in the rest of the county lose the same elevation in two to three times this distance. Because of the steep grade, the stream channels in this area are 20 to 50 feet deeper than they were before channels on the bottom lands were straightened.

Limestone and shale are exposed and quarried in the southeastern corner of the county at the base of the Missouri River bluffs. Soils developed in weathered products of these rocks are not in large enough areas to be mapped separately.

Moderately fine textured soils that have developed from glacial till of Kansan age occur in some places on the lower slopes along the larger streams. Some of the largest areas are along New York Creek. Soils that have developed in loess cover the ridgetops, high terraces, and most of the slopes. Along the streams and drainageways are soils that have developed in alluvial and colluvial materials.

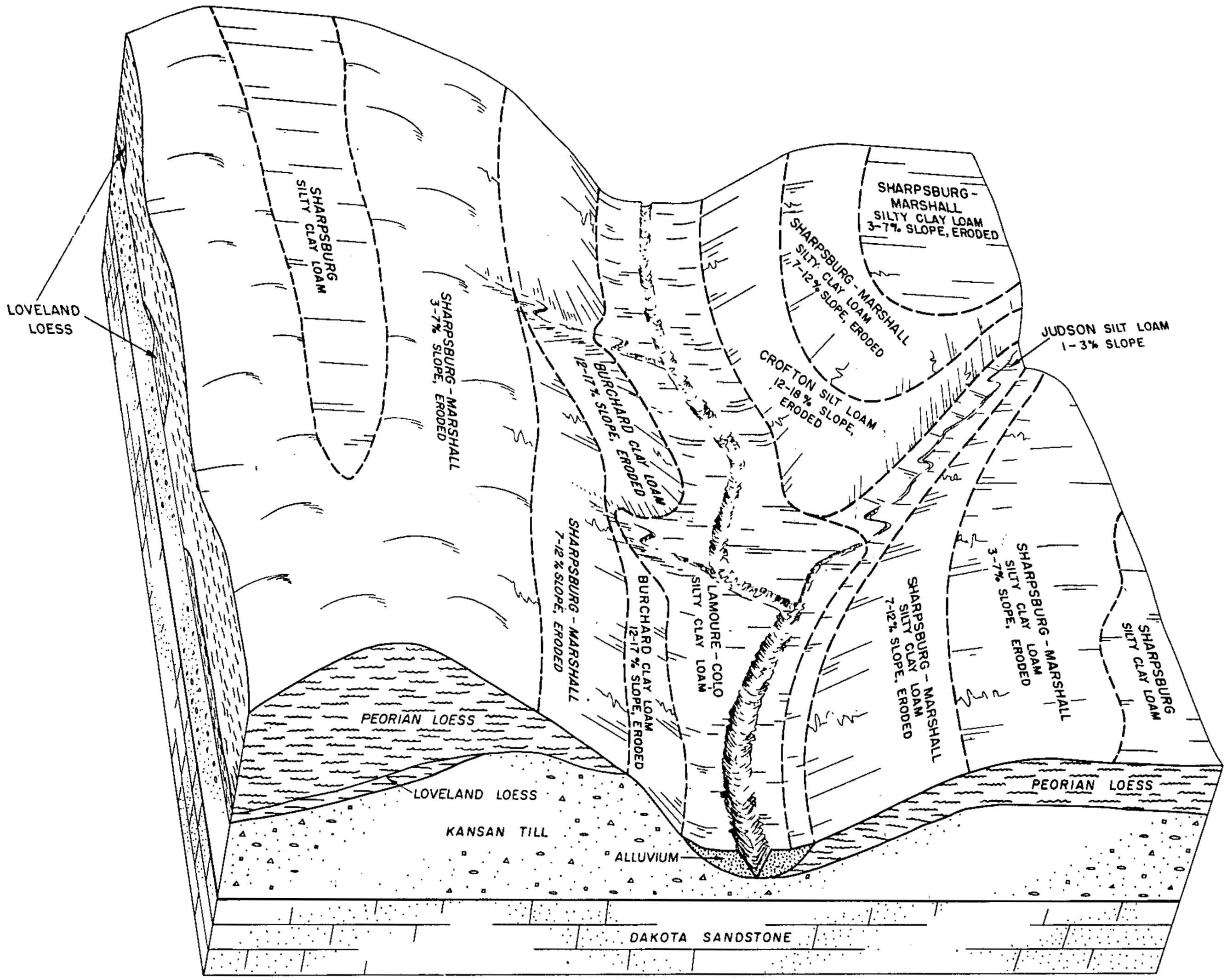

Figure 2.—**Soil pattern of the Sharpsburg-Marshall association.**

The deep, medium-textured Monona and Crofton soils are the most extensive and important ones in this association. Both of these soils have developed in loess and are well drained and permeable. The surface layer is neutral to alkaline in reaction and becomes more alkaline with depth. These soils commonly are calcareous below 5 feet; in places on steep or eroded slopes, they are calcareous at the surface.

The Burchard and Steinauer are less extensive soils that have developed in glacial till. They are on the lower slopes that are rolling to steep. They are moderately fine textured, have moderate profile development, and are calcareous in the lower profile. The Judson and Kennebec soils occur on the colluvial slopes and along the upland drainageways. They are deep, dark, and medium textured and are usually neutral throughout the profile.

Most of this association is cultivated, but it has more land in grass and trees than any other soil association in the county. The more rolling areas have lower yields than other parts of the county and have more of the acreage in alfalfa, rotation hay, and pasture.

5. Luton-Volin association: Clayey to silty soils of the high bottom lands of the Missouri River.

The soils in this association are part of a band of alluvial soils that extend along the eastern edge of the county. These soils are nearly level and have developed in older clayey and silty alluvium next to the terrace. They are about 10 to 30 feet above the frequently flooded, low bottom lands that are along the river channel. This association makes up about 8 percent of the county. The relationship of the soils of the high bottom lands to those of the low bottom lands is shown in figure 4.

Because of the nearly level slopes, all the soils in this association have slow surface drainage. The Luton soils have a fine-textured subsoil and substratum and a medium- to fine-textured surface layer. They are slowly permeable and neutral in reaction. The Volin soils are deep, dark, medium textured, and well drained to moderately well drained. They are more immature than the Salix soils, with which they are associated. The Salix soils occur where a natural levee of silty material was built up adjacent to the low bottom lands. These are deep,

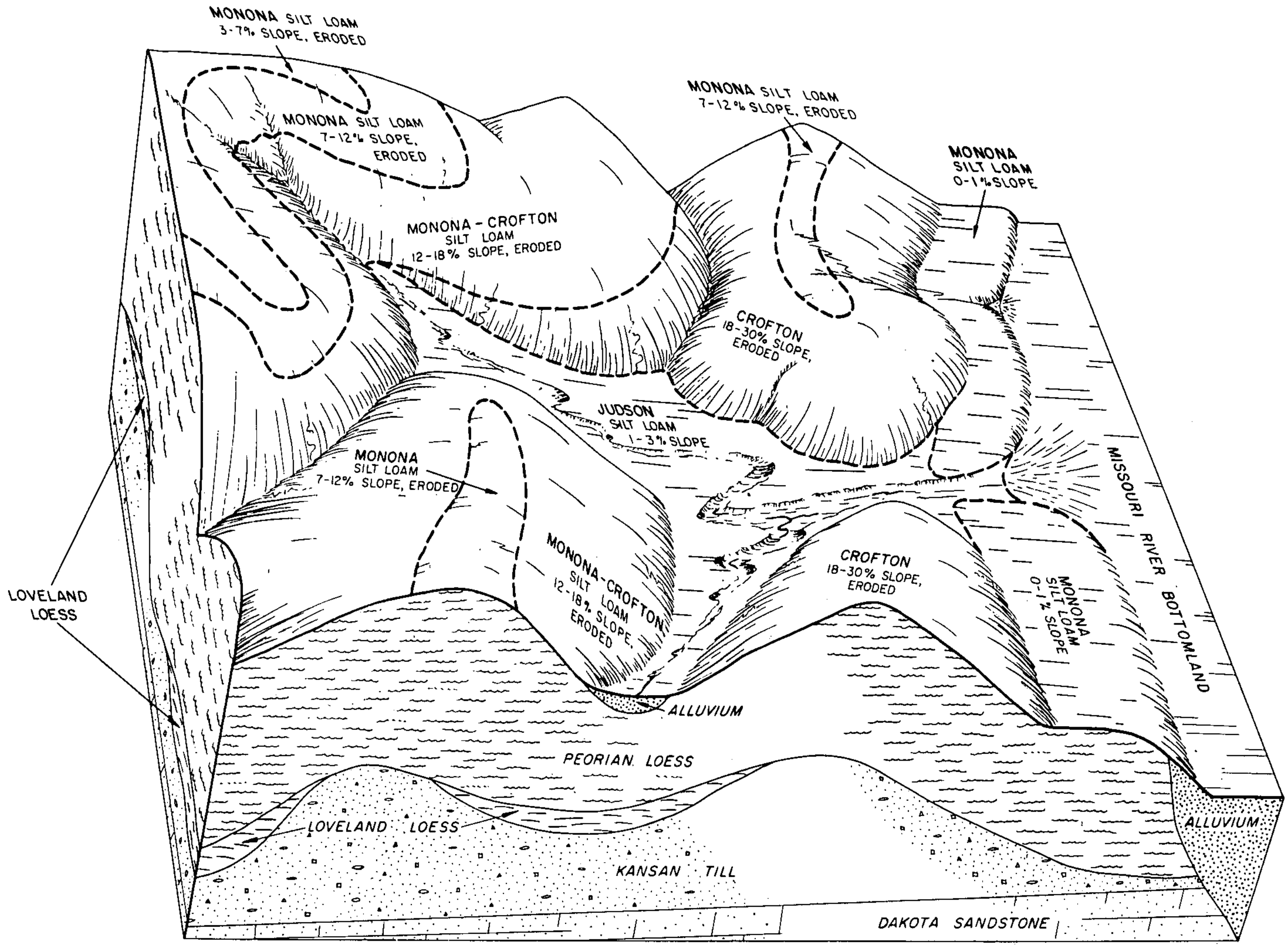

Figure 3.—Pattern *of Monona-Crofton association.*

dark, well-drained silty soils; lime has been leached from their surface soil into the subsoil or below it. The Leshara and McPaul are less extensive soils in this area. They are deep, medium textured, and somewhat immature.

Almost all of the soils in this association are cultivated. Corn, soybeans, sorghum, and alfalfa produce well under good management. Cash-grain farming is the most common type. A few farmers irrigate some of the clay soils planted to seed corn or other special crops to offset the effects of midsummer drought. Gravel roads extend north and south on most section lines, but only a few roads near towns extend west out of the valley.

6. *Albaton-Haynie association: Clayey to sandy soils of the low bottom lands of the Missouri River.*

This association consists of a band of soils, ½ to 2 miles wide, that developed in recent alluvium along the eastern edge of the county. The soils are nearly level, except for those on the short slopes along old channels and drainageways and on a few ridges in the sandy areas. They make up 8 percent of the county.

The Missouri River bottom lands have always been considered two separate areas by the people of the county. Areas of the Luton-Volin association were called the high bottom, and those of the Albaton-Haynie association were called the land below the high bank. The low-lying land has always been subject to seasonal flooding and rapid channel changes. Old pile dikes at a considerable distance from the channel show attempts to stabilize the channel in the 1930's. Then the land was used on a temporary basis. Small fields, 10 to 40 acres in size, were cleared and farmed between floods. The farmsteads were small and frequently were makeshift. A boat for quick exit was a common sight.

From 1940 to 1952, floods caused losses of crops, equipment, and livestock so frequently that people stopped trying to keep the fields cleared, and trees and brush soon covered most of the low bottom lands. The flood of April 1952 was the most extensive in recent years. All of the low bottom lands and most of the high bottom lands were under water. Local deposits of sediment ranged from 1 to several feet thick. After the Fort Randall Dam and other dams in the Dakotas were completed, the probability of

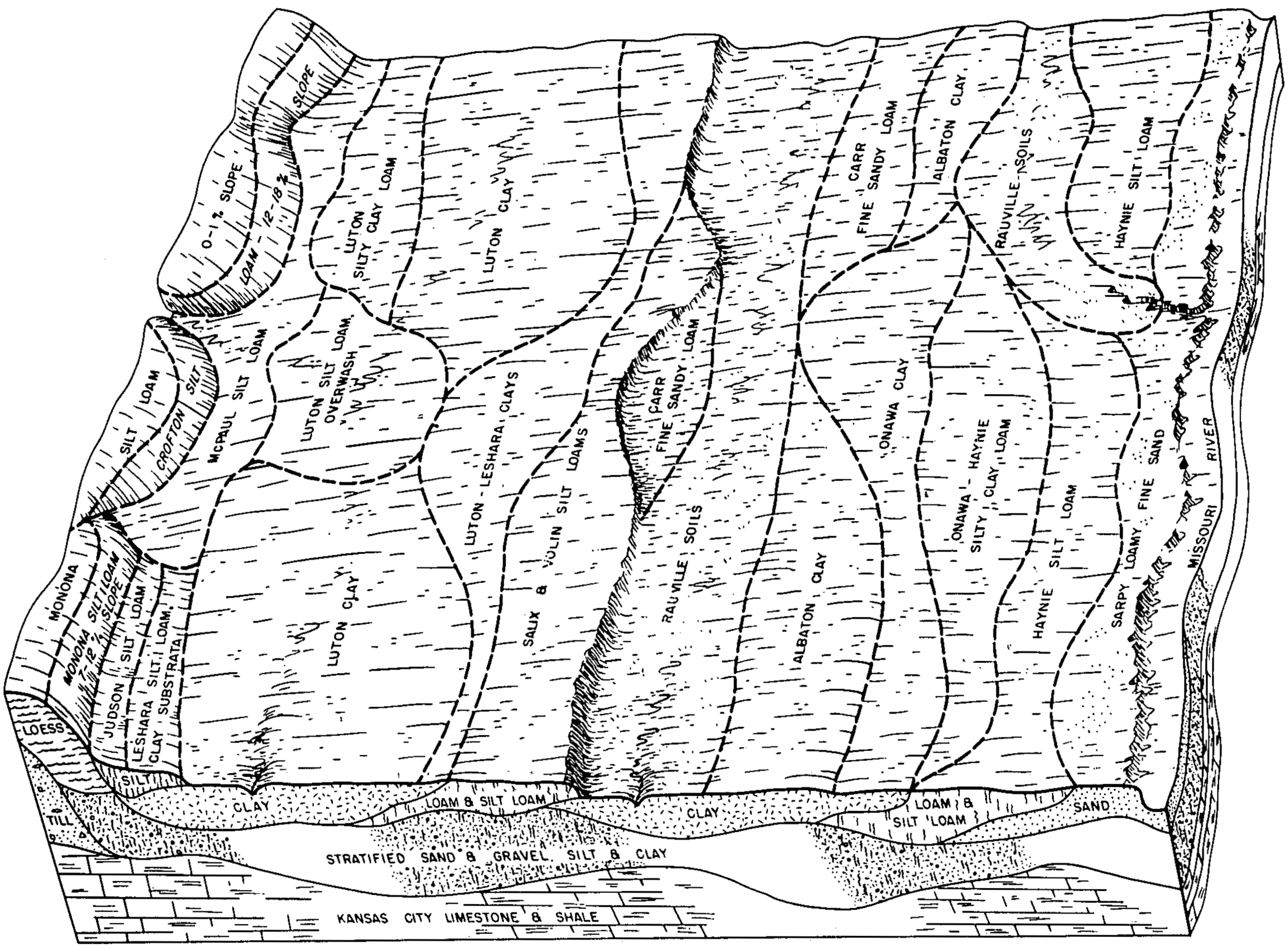

Figure 4.—**Soil pattern of the Luton-Volin and Albaton-Haynie associations.**

flooding was reduced, and the low bottom lands are again being cleared and conditioned for cropping. Large machines are being used to clear the land that a short time ago was covered by trees more than a foot in diameter.

This association is similar in size to the Luton-Volin association. The Albaton, Haynie, and Onawa are the most extensive soils; smaller areas of Rauville, Sarpy, and Carr soils occur. All of these soils are stratified, relatively light colored, immature, imperfectly drained, and calcareous. The Albaton and Onawa soils have developed in the fine-textured sediment. The Haynie, Carr, and Sarpy soils have developed in the coarse-textured sediment. The Rauville soils are in the low, poorly drained areas not suitable for cultivation.

Much of the land in this association is cultivated and produces satisfactory yields if fertilized and well managed. Wet and irregular areas along channels are in trees and brush. These areas are being developed for pasture.

There are fewer farmsteads here than in the rest of the county. Livestock and some cash-grain farming are the most common. Most roads are on section lines, but only those needed to reach the farmsteads and fields have been regraded.

Descriptions of the Soils

In this section each soil series is described, and the general characteristics are given. Each mapping unit is then discussed, and differences from the typical profile are described. The present use, and some of the hazards that limit use, are also given for each mapping unit.

Practically all of the upland soils in Washington County have formed under grass vegetation. Trees originally covered the bottom lands and the lower adjacent slopes. The parent materials of the soils are loess, a silty wind-blown deposit (fig. 5); alluvium, a water-transported deposit; and glacial till, an ice-transported deposit.

The soil characteristics vary considerably; the greatest variation is in the alluvial soils. The texture of the alluvial soils ranges from fine in the clayey soils to coarse in the loamy sands. The permeability ranges from slow to rapid. All gradations between these textures occur in both the surface layer and the subsoil. The soils of the uplands and terraces are quite uniform in texture. They are medium to moderately fine textured in both the surface layer and the subsoil and are moderately to moderately slowly permeable.

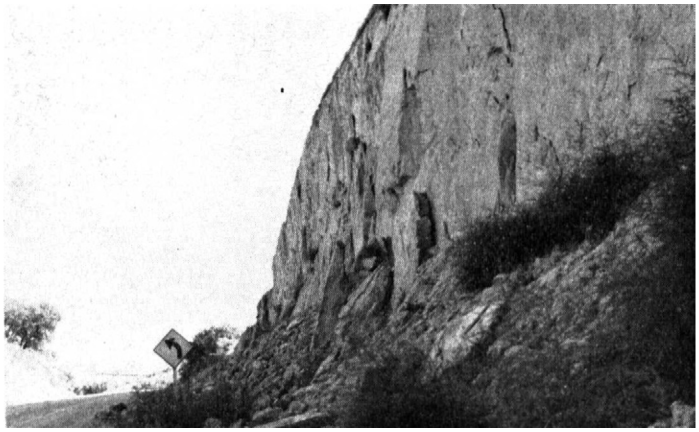

Figure 5.—**A roadcut in loess.**

All of the upland soils are well drained to excessively drained. The bottom lands that are sandy and medium textured or moderately fine textured are well or moderately well drained. The clayey soils are imperfectly to poorly drained.

The acidity of the soils in Washington County varies a great deal. The amount of lime in the soils also varies. Most soils on the low bottom lands are calcareous at or near the surface. The steep and severely eroded soils of the uplands are usually calcareous. The rest of the soils in the county are usually slightly acid in the surface layer, near neutral in the subsoil, and mildly alkaline in the substratum. Free lime is usually present between depths of 2 and 10 feet.

Such soil characteristics and qualities as texture, structure, slope, reaction, content of organic matter, and drainage determine how the soils can be used. Deep, medium-textured, well-drained, level to sloping soils have a wide range in uses. Sandy and steeply sloping soils erode severely in cultivated areas, and their range in use is more limited. Poorly drained soils cannot be cultivated satisfactorily until drainage is improved.

The mapping units, and the map symbols for these units, are listed in the "Guide to Mapping Units and Capability Units" at the end of the report. The approximate acreage of each mapping unit is listed in table 1. The location and distribution of the mapping units are shown on the detailed soil map in the back of the report.

Albaton Series

The Albaton series consists of very recently formed soils on the low bottom lands of the Missouri River. These soils have a silty to clayey surface layer and a clay subsoil, 3 feet or more thick, over stratified sand and silt. They are imperfectly drained, and the water table is from 2 to 5 feet from the surface. These soils are nearly level and have been occasionally flooded by the river. In places they are flooded by small tributary streams.

The surface layer is olive-gray to grayish-brown silt loam to clay, 8 to 18 inches thick. In many places it is darker in the lower part than in the upper part. This layer has a weak, fine, crumb structure and is friable to firm when moist and somewhat hard to hard when dry. The subsoil is olive-gray clay that is lighter colored than the surface layer. It has a moderate, medium, and fine granular structure and is very firm when moist and very hard when dry. The substratum is variable. In some places it is clay, and in others it is stratified sand and silt. It is mottled and streaked with gray and contains fine, distinct iron mottles. The entire profile is calcareous.

The Albaton soils are better drained than the Rauville soils. They are lighter colored and are flooded more frequently than the Luton soils. They have a lighter colored surface layer and a finer textured subsoil than the Lamoure and Colo soils. The Albaton soils are similar to the Onawa soils in drainage, location, and color but have a finer textured subsoil.

Albaton soils are cultivated or are being cleared of trees and brush for cultivation (fig. 6). They produce satisfactory yields of corn, sorghum, soybeans, and wheat if drained and fertilized. Because of imperfect drainage and slow permeability, management of these soils may be difficult. The soils that have a clay surface horizon become cloddy if tilled when wet. Farming operations are delayed in wet seasons.

Fall plowing and adding manure or crop residue will improve the structure of these soils. Because Albaton soils are low in organic matter and nitrogen, they may need phosphate and potassium for highest yields. Introduced pastures of bromegrass, orchardgrass, and reed canarygrass, seeded with a legume, will outyield native species. The native vegetation on these soils was trees.

Albaton clay (Au).—This soil has a profile similar to that described for the Albaton series. It has a clay surface horizon. The slopes range from 0 to 1 percent. Runoff and permeability are both slow. Drainage ditches are feasible in some areas and will help make farming easier. (Capability unit IIIw-1; Moderately wet woodland site.)

Figure 6.—**Clearing trees and brush so that the land may be cultivated.**

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

Soil	Area	Extent
	Acres	*Percent*
Albaton clay	4, 190	1. 7
Albaton silt loam	1, 330	. 5
Belfore silty clay loam	1, 745	. 7
Burchard clay loam, 7 to 12 percent slopes, eroded	970	. 4
Burchard clay loam, 12 to 18 percent slopes, eroded	2, 170	. 9
Carr fine sandy loam	790	. 3
Cass fine sandy loam	700	. 3
Cass loam	750	. 3
Crofton silt loam, 7 to 12 percent slopes, eroded	2, 310	. 9
Crofton silt loam, 12 to 18 percent slopes, eroded	12, 110	4. 9
Crofton silt loam, 18 to 30 percent slopes	1, 645	. 7
Crofton silt loam, 18 to 30 percent slopes, eroded	11, 315	4. 6
Gullied land, Judson materials	3, 595	1. 5
Haynie silt loam	4, 505	1. 8
Judson silt loam, 1 to 3 percent slopes	4, 370	1. 8
Judson silt loam, 3 to 7 percent slopes	14, 535	5. 9
Kennebec silt loam	5, 410	2. 2
Lamoure-Colo silty clay loams	6, 705	2. 7
Leshara silt loam	610	. 2
Leshara soils, clayey substrata	3, 195	1. 3
Luton clay	7, 865	3. 2
Luton and Leshara clays	1, 405	. 6
Luton silty clay loam	3, 850	1. 6
Luton silt loam, overwash	1, 965	. 8
McPaul silt loam	3, 990	1. 6
Monona silt loam, 0 to 1 percent slopes	350	. 1
Monona silt loam, 1 to 3 percent slopes	870	. 3
Monona silt loam, 3 to 7 percent slopes	4, 535	1. 8
Monona silt loam, 3 to 7 percent slopes, eroded	5, 710	2. 3
Monona silt loam, 7 to 12 percent slopes	980	. 4
Monona silt loam, 7 to 12 percent slopes, eroded	6, 690	2. 7
Monona-Crofton silt loams, 12 to 18 percent slopes	510	. 2
Monona-Crofton silt loams, 12 to 18 percent slopes, eroded	9, 080	3. 7
Moody and Marshall soils, 3 to 7 percent slopes	2, 855	1. 2
Moody and Marshall soils, 3 to 7 percent slopes, eroded	10, 370	4. 2
Moody and Marshall soils, 7 to 12 percent slopes	330	0. 1
Moody and Marshall soils, 7 to 12 percent slopes, eroded	5, 800	2. 3
Nora and Crofton soils, 7 to 12 percent slopes, severely eroded	7, 005	2. 8
Nora and Crofton soils, 12 to 18 percent slopes, severely eroded	480	. 2
Nora and Marshall soils, 7 to 12 percent slopes, severely eroded	13, 705	5. 5
Nora and Marshall soils, 12 to 18 percent slopes, eroded	960	. 4
Nora and Marshall soils, 12 to 18 percent slopes, severely eroded	9, 460	3. 8
Nora and Moody soils, 12 to 18 percent slopes, eroded	330	. 1
Onawa clay	1, 885	. 8
Onawa and Haynie silty clay loams	1, 405	. 6
Rauville soils	2, 015	. 8
Riverwash	1, 050	. 4
Salix and Volin silt loams	2, 360	1. 0
Sarpy loamy fine sand	770	. 3
Sarpy loam	780	. 3
Sharpsburg silty clay loam, 0 to 1 percent slopes	7, 785	3. 1
Sharpsburg and Marshall soils, 1 to 3 percent slopes	7, 905	3. 2
Sharpsburg and Marshall soils, 3 to 7 percent slopes	18, 940	7. 6
Sharpsburg and Marshall soils, 3 to 7 percent slopes, eroded	810	. 3
Sharpsburg and Marshall soils, 7 to 12 percent slopes	510	. 2
Sharpsburg and Marshall soils, 7 to 12 percent slopes, eroded	18, 210	7. 4
Spoil banks	500	. 2
Steinauer soils, 12 to 18 percent slopes, eroded	170	. 1
River channel	540	. 2
Total land area	247, 680	100. 0

Albaton silt loam (Ab).—This soil has a profile similar to that described for the Albaton series. It has a silt loam surface horizon. The slopes range from 0 to 1 percent.

This soil, having a medium-textured surface horizon, is easier to till and dries more quickly than soils with a clay surface horizon. (Capability unit IIIw–2; Moderately wet woodland site.)

Belfore Series

The Belfore series consists of deep, moderately fine to fine textured, well-drained soils that developed in Peorian loess. These soils are on the nearly level uplands along the west side of the county and west of Bell Creek.

The surface layer is very dark grayish-brown silty clay loam, 8 to 16 inches thick. The structure in many cultivated areas of this soil is subangular blocky in the plow slice and platy just below. The consistence just below the plow slice is friable. The structure of the surface layer in those areas covered with grass is moderate, medium and fine, granular. The subsurface layer is transitional in color, texture, and structure to the subsoil.

The texture of the subsoil ranges from heavy silty clay loam to silty clay; in this county it is usually heavy silty clay loam. The color is brown; and the structure is weak, medium, prismatic that breaks to moderate, medium and fine, subangular blocky. The consistence is slightly firm. Thin, continuous clay films coat the aggregates. The thickness of the subsoil ranges from 30 to 40 inches.

The substratum is brown silty clay loam that has a weak, coarse, prismatic structure. There are common, brown mottles in the substratum and a few, distinct, fine, very dark brown concretions. The Belfore soils grade from medium acid in the surface layer to neutral in the substratum.

The Belfore soils occur on the ridgetops in association with the Marshall, Moody, and Nora soils, which are on the slopes. The Crofton soils are in the adjacent steeply sloping or severely eroded areas. The Belfore soils are somewhat more leached, have a finer textured subsoil, and are on more level slopes than the associated soils.

Most of the Belfore soils are cultivated. They produce high yields of all the crops adapted to the county. They take in moisture well and are easily tilled. The native vegetation was tall prairie grass.

Belfore silty clay loam (Bs).—The profile of this soil is similar to that described for the series. Slopes range from 0 to 3 percent, but in most areas they are less than 3 percent. A few areas on steeper slopes are included.

This soil produces excellent crops of corn, oats, and clover and good yields of wheat, soybeans, and alfalfa. Nitrogen improves the yield of crops other than legumes. In some areas phosphate benefits crops, especially legumes, and lime helps get a stand of alfalfa. The amount of plant nutrients needed should be determined by soil tests. (Capability unit IIe-1; Silty to clayey woodland site.)

Burchard Series

The Burchard series consists of moderately fine to fine textured, well-drained soils that developed in glacial till. The only significant areas are in the Missouri River bluff zone, but a few areas are scattered throughout the uplands. The soils are on the lower slopes along the deeply entrenched streams. On these rolling to steeply rolling slopes, stream cutting has exposed the till under the loess.

The surface layer is moderately thick, dark gray, and moderately fine textured. It has a granular structure and ranges from 6 to 12 inches in thickness. The subsoil is dark grayish brown to brown and has a weak, coarse, prismatic structure that breaks to fine, subangular blocky. Its texture is somewhat finer than that of the surface layer. Lime has accumulated in the lower part of the subsoil. The substratum is light brownish-gray, fine-textured till that has many yellowish-brown mottles and dark-brown concretions. The Burchard soils range from slightly acid in the surface layer to alkaline in the calcareous substratum.

These soils are associated with the Steinauer that have developed on till but have thinner profiles and are generally on steeper slopes. The associated Monona soils, which developed in loess, are on the same slopes with the Burchard soils.

About 95 percent of these soils is cultivated. Yields are only moderate, however, because of the steep slopes and the degree of erosion. The native vegetation was grass and trees on some of the lower slopes.

Burchard clay loam, 7 to 12 percent slopes, eroded (BdC2).—This soil has a surface horizon that is 8 to 14 inches thick (fig. 7). It has moderate slopes and is moderately eroded. It holds water well for plants but absorbs it more slowly than the soils on loess.

Most of the crops commonly grown in the county can be grown on this soil. Cultivated areas not adequately protected have been damaged by erosion. (Capability unit IIIe-1; Silty to clayey woodland site.)

Burchard clay loam, 12 to 18 percent slopes, eroded (BdD2).—This soil has a profile similar to that described for the Burchard series. Because of the steeper slopes, this soil has a thinner surface horizon, is more severely eroded, has lime nearer the surface, and is more difficult to farm than the Burchard soil on 7 to 12 percent slopes.

Because of a lower fertility and thinner soil, erosion is more active and is difficult to control. Erosion can be controlled by a cropping system in which row crops are grown only 1 year in 5, and small grain and hay and pasture crops are grown the rest of the time. (Capability unit IVe-1; Silty to clayey woodland site.)

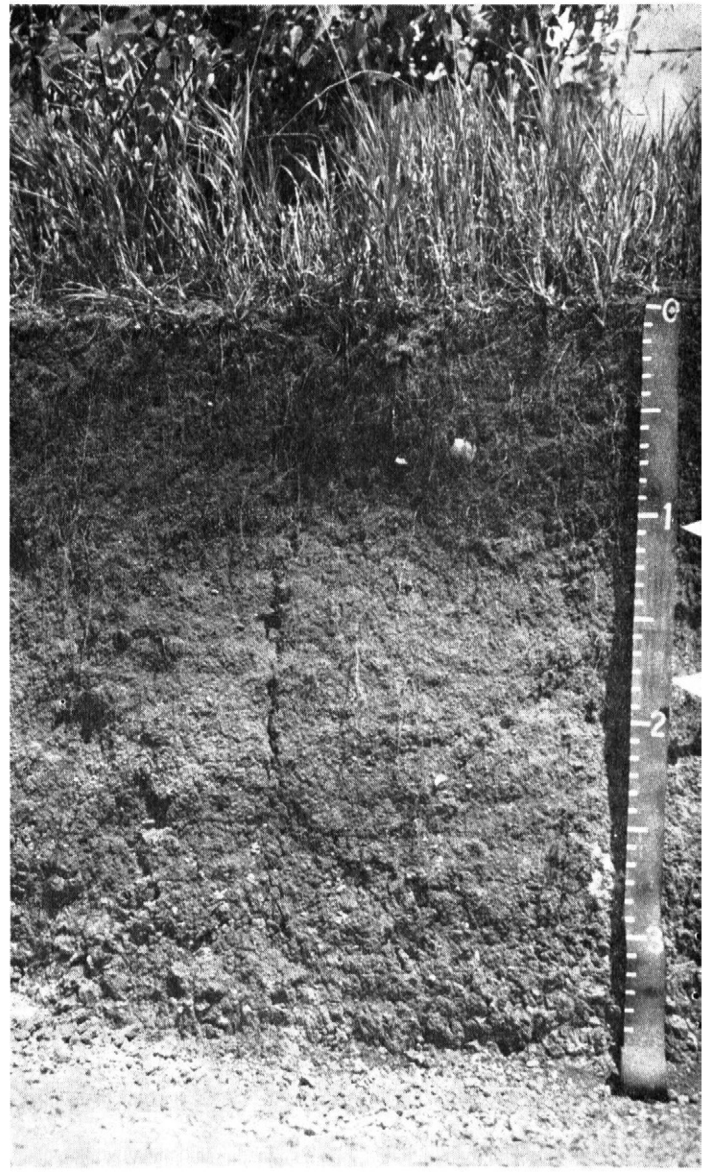

Figure 7.—**Profile of Burchard clay loam.**

Carr Series

In the Carr series are deep, nearly level soils in the low bottom lands of the Missouri River. These soils were formed in recent calcareous alluvium under the influence of a moderately high water table. They have a moderately coarse textured subsoil that in many places is stratified with coarser and finer material. These soils are usually calcareous to the surface and are rarely mottled. They are moderately well drained and have a water table that is 2 to 5 feet from the surface.

The surface layer is calcareous, light-colored, pale-brown fine sandy loam, 6 to 10 inches thick. It has weak, very fine, crumb structure. In many areas the surface layer was deposited by the 1952 flood. The subsoil is grayish-brown fine sandy loam that is strongly calcareous and has weak, crumb structure. In places it is transitional to the substratum in texture and color. In some places the substratum is stratified very fine sandy loam to loamy fine

Figure 8.—**Area of Carr soils that is being cleared for farming.**

sand, and in others it is a darker horizon that was the surface layer of a former soil.

The Carr soils are similar in texture to the Cass soils but are lighter colored and are less well drained. They are similar in color, location, and drainage to the associated Haynie and Onawa soils but are coarser textured. They are finer textured and thicker than the Sarpy soils in the same general area of the bottom lands, but otherwise they are similar.

While the low bottom lands were being frequently flooded, many areas of these soils were allowed to return to trees. These areas, however, have been cleared for cultivation (fig. 8), or are now being cleared. Corn is grown most extensively on these soils; oats, rye, and alfalfa are also important crops. Because they have not been cultivated long, these soils need nitrogen, phosphate, and organic matter for satisfactory production of crops. The native vegetation was trees.

Carr fine sandy loam (Cg).—The profile of this soil is much like the one described for the Carr series. The slopes range from 0 to 1 percent. Areas of this soil vary a great deal within a short distance, however. Because of stratification, the profile is quite variable in texture.

Crop yields are fair, but wind erosion is a hazard while crops are being established. (Capability unit IIIw-6; Moderately wet woodland site.)

Cass Series

The Cass series consists of well-drained, deep soils of the bottom lands. These soils formed in recent alluvium. Except in a few areas on ridges and the slopes of shallow channels, they are nearly level. Because of the sandy subsoil, internal drainage is moderately rapid. The water table fluctuates from 3 to 10 feet below the surface.

The surface layer is dark-gray loam that ranges from 10 to 20 inches in thickness. It has weak, fine, granular structure and is friable when moist. The subsoil is grayish-brown fine sandy loam that is very friable when moist and has weak, coarse, prismatic structure. In many areas, iron stains and mottles are in the lower subsoil. Also in many areas, the upper part of the substratum and the lower subsoil are stratified with silt. The sandy substratum contains a mixture of gravel in places. Generally, there is no lime in the solum.

The Cass soils occur with the Leshara, Lamoure, and Sarpy soils, which are usually less well drained. They have a coarser textured subsoil than the Leshara and Lamoure soils. The Cass soils have a finer textured subsoil and a thicker, darker colored surface layer than the Sarpy soils.

Because the Cass soils are in the higher parts of the Elkhorn River bottom lands, they are flooded only in years of extremely high water. Almost all of these soils are cultivated. All crops suited to the county are grown. Yields of corn, sorghum, and alfalfa are especially good. Nitrogen fertilizer is needed for maximum yields. These soils are easily worked. The moisture-holding capacity of the subsoil, however, is less than that in subsoils with a finer texture. The native vegetation was tall grass and scattered trees.

Cass loam (Cm).—This soil has a profile like that described for the Cass series. The surface layer ranges from 10 to 20 inches in thickness. Small areas with a fine sandy loam surface layer are included with this soil in places. Sand occurs at a depth of 3 to 6 feet; little gravel occurs in the substratum. The slopes range from 0 to 1 percent. The surface is nearly level except in channeled areas.

Most of this soil is cultivated; it produces good yields of the commonly grown crops. (Capability unit I-1; Silty to clayey woodland site.)

Cass fine sandy loam (Cs).—This soil has 25 to 40 inches of fine sandy loam over sand or coarse sand. The profile becomes coarser with depth. The surface layer is lighter colored than that of Cass loam. The slopes range from 0 to 1 percent.

Most areas are cultivated and are easily tilled. Crops respond well; however, wind erosion is a hazard when the ground is not covered with a growing crop or by crop residue. (Capability unit IIe-3; Sandy woodland site.)

Colo Series

The Colo series consists of deep, dark, nearly level soils that developed from alluvium along the drainageways of the uplands in the central and western parts of the county. These soils are imperfectly drained and are moderately fine textured.

The upper layer is friable, dark-gray to nearly black silty clay loam, 20 to 30 inches thick. It has granular structure. The substratum is gray to very dark gray, massive silty clay loam to silty clay that has a few, faint, fine, yellowish-brown mottles in places. A few lime concretions also occur in places. Between the surface layer and the substratum, a 10- to 20-inch layer occurs that is transitional in color and structure. These soils are alkaline; but except for a few scattered concretions, they do not contain lime.

The Colo soils are slowly permeable because of their moderately fine texture, and they have slow surface drainage because of their nearly level relief. Consequently, tillage is delayed in wet years. If properly managed, these soils produce good yields of corn, soybeans, wheat, and alfalfa. The native vegetation was tall prairie grass.

In this county the Colo soils are mapped only in a complex with the Lamoure soils, which are calcareous in the lower part of the profile.

Crofton Series

The soils of the Crofton series are thin and moderately dark. The profile has little texture or structure differentiation and, in eroded areas, has little color differentiation. These soils are on rolling to steep slopes of the uplands. These slopes range from 7 to 30 percent or more. The soils are well drained to excessively drained. Lime occurs in many places in the subsoil of virgin profiles and at or near the surface of the eroded soils.

In areas that are not eroded, the surface layer is very friable, grayish-brown to very dark grayish-brown silt loam, 4 to 10 inches thick. It has a weak, fine, granular structure and is noncalcareous. The subsoil is dark brown to brown and is similar to the surface layer in consistence and structure. The parent loess is light olive-brown silt loam that is calcareous in many places. It is massive, but coarse prisms frequently fall away from vertical exposures of the parent loess (fig. 9). Small concretions of hard lime and iron stains are in the parent material in many places.

The Crofton soils have a thinner surface horizon and have lime higher in the profile than the Monona soils. They are coarser textured than the Steinauer and Burchard soils and do not contain stone and gravel as do these soils. The Crofton have a thinner surface horizon, have less profile development, and are generally on steeper slopes than the Marshall, Moody, and Sharpsburg soils.

Most cultivated areas of Crofton soils have lost much of their darker surface horizon. Only the less rolling areas of these soils are suitable for cultivation. Corn, wheat, and oats are grown. Bromegrass and alfalfa are grown for hay and pasture. All crops respond to nitrogen and to a lesser extent to phosphate. Applications of lime are not needed.

Bluestems, Indiangrass, and switchgrass occur on the smoother areas of steep slopes that have not been cultivated or that have been returned to native vegetation. Oak and elm trees are on the steep slopes and along the entrenched drainageways.

Crofton silt loam, 7 to 12 percent slopes, eroded (CfC3).—Most of this soil has been cultivated, and erosion has removed part of the dark-colored surface horizon. Yields of corn or sorghum, oats, wheat, and alfalfa are fair to good. The yields depend on the degree of erosion and the level of fertility. (Capability unit IIIe–8; Silty to clayey woodland site.)

Crofton silt loam, 12 to 18 percent slopes, eroded (CfD3).—This soil is on moderately steep slopes between the ridgetops and drainageways. As a result of cultivation, much of the dark surface horizon has been lost. Crop yields are reduced because of the low amount of organic matter. Plant nutrients must be added to obtain satisfactory yields of corn, wheat, or oats. If cultivated crops are grown for short periods, and followed by several years of grass and legumes for hay or pasture, production can be maintained. (Capability unit IVe–8; Silty to clayey woodland site.)

Crofton silt loam, 18 to 30 percent slopes (CfE).—This soil is on steep and broken slopes that have remained in grass or trees. Irregular "catstep" slopes occur in the most steeply sloping areas.

The dark surface horizon is thinner than that described for the Crofton series, and in places the soil is calcareous at or near the surface. The native grass consists of bluestem, side-oats grama, and switchgrasses. Oak and elm are the most numerous trees. (Capability unit VIe–1; Silty to clayey woodland site.)

Figure 9.—**An area of Crofton soils showing a thin surface horizon and coarse, prismatic structure in the substratum.**

Crofton silt loam, 18 to 30 percent slopes, eroded (CfE3).—This soil is on steep slopes that have been cultivated. The dark surface horizon has been removed by erosion, and in most places, the light-colored, calcareous parent loess has been exposed. This soil should not be cultivated. It should be returned to grass or trees. (Capability unit VIe–8; Silty to clayey woodland site.)

Gullied Land

Gullied land, Judson materials (Gl).—This miscellaneous land type consists of areas along drainageways that have been deeply cut by gully erosion (fig. 10). Before erosion, these areas were occupied by deep, dark alluvial soils. The soils were similar to Judson silt loam, 1 to 3 percent slopes. Remnants of these soils remain along the gully banks.

This land type was formed mainly as the result of work done to stabilize the course of the Missouri River. Drainage channels were cut through low bottom lands, and these channels are now 4 to 20 feet below former stream level. Lowering the channels caused headward cutting of gullies and thus the formation of this land type.

This land type is not suited to cultivation or grazing. Structures for gully control are needed in many places (fig. 11). Trees and brush cover many areas and also help to stabilize the eroding streambank. (Capability unit VIIIe–1; woodland site not assigned.)

Figure 10.—Area of Gullied land.

Haynie Series

The soils of the Haynie series are deep, medium textured, and imperfectly drained. They developed on the low bottom lands of the Missouri River in recent, light-colored alluvial deposits that frequently are stratified with lenses of clay loam and sandy loam. These soils are nearly level but have a few channels.

The surface layer is dark grayish-brown silt loam, 6 to 12 inches thick. This layer is usually calcareous and has weak, fine, granular structure and friable consistence. The subsoil is usually lighter colored than the surface soil and has similar texture. It is transitional in color between the surface layer and the parent material. The parent material is at a depth of about 20 inches. It is light grayish brown and in many places has brown and yellowish-brown mottles. In places this material is stratified at varying levels with narrow clayey or sandy layers, and it is strongly calcareous. The water table is from 2 to 6 feet below the surface.

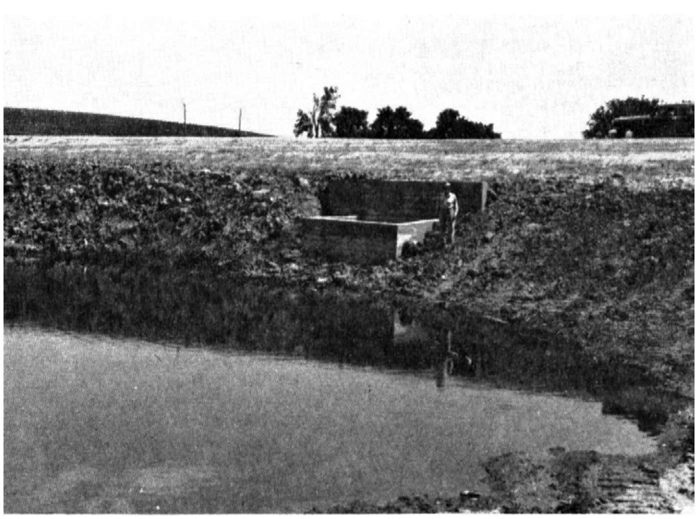

Figure 11.—A drop inlet that helps to control gully erosion.

The Haynie soils are associated with the Albaton, Onawa, and Sarpy soils. They are better drained than the Albaton and Onawa soils because water remains longer on these lower lying, finer textured soils. They are not so well drained as the Sarpy soils, which occur on ridges and are coarser textured.

The Haynie soils are usually easy to till but produce only fair to good crops of corn, sorghum, and alfalfa. The low content of organic matter indicates that nitrogen may be lacking. Because these soils are low in organic matter and are high in lime, the available phosphorus is low. Most areas have been cleared of trees and shrubs and are cultivated.

Haynie silt loam (He).—This soil has a profile similar to the one described for the series. The slopes range from 0 to 1 percent. Some areas are cut by channels, 1 to 4 feet deep and 5 to 15 feet wide. Most of these channels can be crossed by farm machinery. (Capability unit IIw-4; Moderately wet woodland site.)

Judson Series

In this series are deep, dark silty soils that have formed on colluvial-alluvial slopes and fans along stream bottom lands and on the valley floors of the narrow streams. The dark-colored silty parent material of these soils was washed from adjacent sloping uplands. These soils occur along the smaller streams throughout the uplands.

The surface layer is dark-colored silt loam, 20 to 30 inches thick. It has granular structure. A transitional layer separates the surface layer from the substratum. It is similar to the surface layer in texture and structure but is lighter colored. The substratum is grayish-brown silt loam to silty clay loam and is granular in structure. The entire profile is usually noncalcareous.

The Judson soils occur between the Kennebec soils and Lamoure-Colo silty clay loams of the bottom lands and the Marshall, Monona, Moody, and Nora soils of the upland slopes.

Most of the acreage of the Judson soils is cultivated. These soils are among the most productive in the county. They are well supplied with organic matter, are easy to till, and take in and release moisture readily. Corn and hay crops yield well; small grain sometimes lodges. Areas of these soils on nearly level slopes are subject to flooding during heavy rains, and those along the drainageways are subject to gully erosion. When not cultivated, these soils support a thick stand of tall prairie grass.

Judson silt loam, 1 to 3 percent slopes (JuA).—This soil occurs on the more level areas along stream bottoms. In places some stratification is evident. Entrenched drainageways in some areas require shaping and seeding to grass. (Capability unit I-1; Silty to clayey woodland site.)

Judson silt loam, 3 to 7 percent slopes (JuB).—This soil has a profile similar to the one described for the Judson series. It is on slopes between the bottom lands and the uplands. (Capability unit IIe-1; Silty to clayey woodland side.)

Kennebec Series

In the Kennebec series are deep, silty soils that developed from alluvium along streams of the uplands, principally in the eastern part of the county. They are nearly level except where there are drainage channels of intermittent streams.

The surface layer consists of 10 to 20 inches of very dark grayish-brown silt loam that has granular structure. A transitional layer separates the surface layer from the substratum. This layer is similar to the surface layer in texture and in structure but is lighter in color. The substratum is dark-brown to brown silt loam that is granular to massive. These soils are stratified in many places, and their profile is generally noncalcareous.

These soils occur along streams below the Judson soils and in association with McPaul soils. The Kennebec soils are older and developed in more stratified material than the Judson soils. They lack the lighter colored surface deposit of the McPaul soils.

The Kennebec soils are among the most productive and most easily tilled soils in the county. Most areas are cultivated. These soils are high in organic matter and are naturally fertile. They are seldom flooded, and in dry years their additional moisture increases production. The native vegetation on most of these soils was tall prairie grass.

Kennebec silt loam (Ke).—This soil has a profile like the one described for the Kennebec series. Slopes range from 0 to 1 percent. (Capability unit I-1; Silty to clayey woodland site.)

Lamoure Series

The Lamoure series consists of deep, dark, moderately fine textured soils. These soils are nearly level and have developed in stream-deposited material along the upland drainageways in the western two-thirds of the county. The Lamoure soils are imperfectly to somewhat poorly drained and are calcareous. The water table is from 2 to 10 feet below the surface layer.

The surface layer is friable, very dark gray to black silty clay loam, 10 to 20 inches thick. It has granular structure. Between the surface layer and the substratum is a 10- to 15-inch transitional layer that is similar to the surface layer in color but has a somewhat finer texture and stronger structure. This layer is calcareous. The substratum is dark-gray silty clay and has a few gray mottles. It is massive and strongly calcareous.

The Lamoure soils are more calcareous at a shallower depth than the Colo soils. They have a finer textured subsoil than the Leshara soils. The Lamoure soils are not so fine textured as the Luton soils.

The slow permeability and slow surface drainage of the Lamoure soils may delay tillage. Consequently, yields may be reduced because of late planting and lack of weed control. If properly fertilized, these soils will produce good yields of corn, soybeans, wheat, and alfalfa in years when tillage is not delayed. The native vegetation on these soils was tall prairie grass.

In this county the Lamoure soils are mapped only in a complex with the Colo soils.

Lamoure-Colo silty clay loams (LC).—This mapping unit consists of areas of Lamoure and Colo silty clay loams that were too closely associated or intricately mixed to be mapped separately at the scale used. The Lamoure soils make up from 20 to 50 percent of this complex of soils. The slopes range from 0 to 1 percent.

The soils in this complex are similar in most ways; however, the Lamoure soils are calcareous in the lower part of the profile and in many areas occupy slightly lower positions than the Colo soils.

In years of above-normal rainfall, yields from the soils of this complex are reduced. In drier than normal years, yields are higher than those from the average soil of the uplands.

Typical Colo soils are described under the Colo series. (Capability unit IIw-4; Moderately wet woodland site.)

Leshara Series

The Leshara series consists of imperfectly drained, nearly level soils of the bottom lands. They developed in loamy to silty alluvial deposits. The soils of this series along the Elkhorn River are loamy throughout the profile. On the Missouri River bottom lands, there are Leshara soils with a clayey substratum.

The dark-gray to black surface layer ranges from silt loam to clay in texture, has granular structure, and is friable. The Leshara soils have a moderately dark, silty to loamy subsoil that occurs at a depth of 10 to 20 inches and is 10 to 20 inches thick. The substratum is stratified; it is mainly loamy but is clayey where silty and loamy material covers clay alluvium. Except for lime in the substratum, these soils are noncalcareous. The water table is usually 3 to 15 feet below the surface.

Along the Elkhorn River, the Leshara soils are associated with the Cass soils, which have a sandier subsoil. In some areas they are associated with the Lamoure-Colo soils, which have a moderately fine textured subsoil. On the Missouri River bottom lands, they are associated with the Luton soils, which have a clay subsoil and substratum.

The Leshara soils are very fertile and are cultivated in most areas. In all years but those of excessive moisture, they produce good yields of corn, sorghum, soybeans, wheat, and alfalfa. Because of their imperfect drainage and high water table, these soils are more difficult to manage in wet years. The Leshara soils, clayey substrata, have slower internal drainage than other Leshara soils, and wetness is a somewhat greater problem. The Leshara soils support tall native prairie grass.

Leshara silt loam (Le).—This soil has a profile similar to the one described for the Leshara series. The slopes range from 0 to 1 percent. (Capability unit IIw-4; Moderately wet woodland site.)

Leshara soils, clayey substrata (2Le).—These soils are in areas of the Missouri River bottom lands where 2 to 3 feet of silty to loamy alluvium were deposited over clay. These areas are adjacent to Luton soils. The slopes range from 0 to 1 percent. Leshara soils, clayey substrata, are calcareous and have mottles higher in the profile than Leshara silt loam. (Capability unit IIw-3; Moderately wet woodland site.)

Luton Series

The Luton series consists of deep, clayey soils of the bottom lands. These soils have developed in clayey, stream-deposited materials. Because of their nearly level slopes and slow permeability, they are somewhat poorly drained. They are on the higher part of the bottom lands, however, where the water table is usually 10 feet below the surface. The Luton soils are most extensive on the bottom lands along the Missouri River. They also occur along Bell Creek in the western part of the county.

The surface layer is very dark gray to black clay, is 10 to 20 inches thick, and is granular in structure. Below this layer is a transitional layer that has about the same texture but has coarser structure and lighter color. The substratum is gray to dark grayish-brown, blocky clay that is mottled and gleyed in the lower part. These soils are alkaline throughout and are usually calcareous, especially in the lower part of the profile. Buried soils are common.

The Luton soils are associated with the Lamoure-Colo silty clay loams along Bell Creek and with the Leshara soils along the Missouri River. They are finer textured and are more poorly drained than the soils with which they occur.

Under ideal moisture conditions, these soils are fertile and productive. They are difficult to manage because they can be tilled only within a narrow moisture content. It is difficult to obtain stands and to control weeds. Corn, soybeans, and wheat are the principal crops. After stands have been established, alfalfa yields are satisfactory. Tall prairie grass, mixed with wetland grass, was the native vegetation.

Luton clay (Lu).—The profile of this soil is similar to that described for the series. The slopes range from 0 to 1 percent. (Capability unit IIIw–1; Moderately wet woodland site.)

Luton and Leshara clays (LLu).—The soils of this undifferentiated unit occur on the Missouri River bottom lands where Luton clay is associated and intermixed with the Leshara clays. The Leshara clays make up about 40 percent of most areas. The slopes of Luton and Leshara clays range from 0 to 1 percent.

The Leshara clays have a dark, fine-textured surface horizon over a lighter colored, medium-textured subsoil and stratified substratum. These areas have the same capacity to produce crops and the same management problems as Luton clays.

Typical Leshara soils are described under the Leshara series. (Capability unit IIIw–1; Moderately wet woodland site.)

Luton silty clay loam (Ls).—The profile of this soil is similar to the one described for the series, but the surface layer is coarser textured. This soil occurs along Bell Creek (fig. 12) and is the result of the slow accumulation of material that washed from surrounding hills. The slopes range from 0 to 1 percent.

This soil is dark colored to a greater depth, is less mottled, and contains more silt throughout the profile than Luton clay. The upper 20 to 30 inches are generally noncalcareous. Both disseminated and concretionary lime occur below this depth.

Many areas were poorly drained until Bell Creek was straightened and deepened. Since then, most areas have been plowed and are used for cultivated crops. (Capability unit IIw–4; Moderately wet woodland site.)

Luton silt loam, overwash (Lt).—The profile of this soil differs from the profile described for the Luton series in having a medium-textured surface layer. This surface layer has been washed onto areas of Luton clay from the adjoining silty uplands. This overwash layer ranges from light to moderately dark in color and from 6 to 20 inches in thickness.

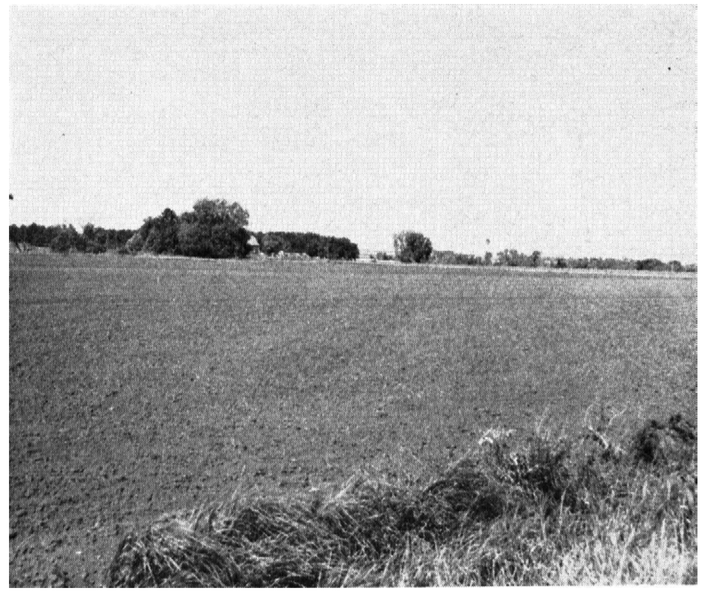

Figure 12.—**Luton silty clay loam on Bell Creek bottom land.**

Luton silt loam, overwash, is more easily tilled and takes in water more rapidly than Luton clay. (Capability unit IIw–4; Moderately wet woodland site.)

Marshall Series

The Marshall series consists of deep, dark soils that developed in loess on the gently sloping to rolling uplands. These soils are most extensive in the central part of the county between Bell Creek on the west and the Missouri River bluff zone on the east.

In areas that are only slightly to moderately eroded, the surface layer is 10 to 15 inches of dark grayish-brown, light silty clay loam. It has granular structure. The subsoil is brown to dark yellowish-brown silty clay loam. It has moderate, medium, subangular blocky structure and is 15 to 30 inches thick. The substratum is yellowish-brown light silty clay loam or silt loam and has weak, coarse, prismatic structure. Throughout the solum, the Marshall soils are noncalcareous and are slightly acid, but their substratum is neutral.

The Marshall soils are associated with the Sharpsburg, Moody, and Nora soils. They are similar to the Sharpsburg soils, but their slopes are steeper, and their profile layers are less distinct. The Marshall soils have developed on smooth and concave slopes in loess that contains less lime than the parent material of the Nora soils. In most areas the Nora soils are on convex slopes, on the points and shoulders where erosion has been most active, and where the parent material is calcareous and is older than that of the Marshall soils. The Marshall soils are similar to the Moody soils, but are not so calcareous, are slightly more friable, and are less clayey.

The Marshall soils are among the most productive in the county and are nearly all cultivated. Because they take in and hold moisture well, they are easy to cultivate within a relatively wide range in moisture content. These soils are fertile but need additional nitrogen for maximum production. Lime and phosphate may benefit legume seedings. Potassium is adequate for field crops. Conservation practices are needed to reduce runoff and to protect the surface soil from erosion. The native vegetation was tall prairie grass.

In this county the Marshall soils have been mapped only in undifferentiated units with the Moody, Nora, and Sharpsburg soils.

McPaul Series

The McPaul series consists of nearly level silty soils that developed in alluvium. These soils are along the streams in the uplands or on fans where light-colored silty material from the uplands has washed over the medium-textured material of the bottom lands. The most extensive areas are along drainageways adjacent to steep, actively eroding uplands in the eastern part of the county. The water table is 5 to 20 feet below the surface.

The surface layer is recent overwash consisting of dark-gray to grayish-brown, granular silt loam. An abrupt boundary separates this layer from the dark (frequently black) surface layer of a buried Kennebec or Leshara soil. This buried surface layer is 10 to 20 inches thick, medium textured, and granular. Below this is a transitional layer and the substratum of the buried Kennebec or Leshara soil.

Adjoining areas of the McPaul soils are Kennebec and Leshara soils that were not covered with the overwash or had a thin cover that was lost through cultivation. Where erosion control practices have reduced the wash from the uplands, the McPaul soils are being darkened by an accumulation of organic matter.

The McPaul soils are mostly cultivated and are productive and easily tilled. They are well suited to corn and soybeans, but heavy rain sometimes causes crop losses. The most serious hazard is crop damage from flooding. The native vegetation was tall prairie grass.

McPaul silt loam (Mc).—This soil has a profile similar to the one described for the McPaul series. The slopes range from 0 to 1 percent. In areas protected from floods, this soil is excellent for crops. It develops a dark surface layer as organic matter accumulates. (Capability unit IIw-3; Moderately wet woodland site.)

Monona Series

The Monona soils are well-drained, nearly level to steeply sloping silty soils of the uplands. They have developed in thick deposits of silt loam loess on the eastern one-third of the uplands (the Missouri River bluff zone) and on the bluffs along the Elkhorn River.

The Monona soils have weakly developed profiles that are silt loam to light silty clay loam in texture (fig. 13). The dark brown to very dark brown silt loam to silty clay loam surface layer is 6 to 12 inches thick. It has granular structure. The weakly developed light silty clay loam to silt loam subsoil is 15 to 30 inches thick. It has weak, subangular blocky structure. The parent loess is pale-brown, massive silt loam that is mottled in places. These soils are noncalcareous in most areas and have a slightly acid surface layer and subsoil and an alkaline substratum.

Figure 13.—**Profile of Monona silt loam.**

The Monona have less profile development than the Marshall soils, but more development than the Crofton.

The Monona soils are very well suited to crops, as they are easily tilled within a wide moisture range. They take in and hold moisture well. Except on some of the steeper slopes, all of these soils are cultivated. If erosion is controlled, these soils are fertile and produce satisfactory yields of all the crops grown in the county. They respond to nitrogen and phosphate fertilizers, especially in eroded areas. Lime is seldom needed. The native vegetation was tall prairie grass on most areas and scattered trees on the lower part of the steepest slopes.

Monona silt loam, 0 to 1 percent slopes (Mn).—This soil has a profile similar to the one described for the Monona series. It has more profile development than any of the other soils of the series. It occurs on the nearly level divides in the Missouri River bluff zone and on the loess-covered terraces between the bluffs and the Missouri River bottom lands.

Little erosion has occurred, but drainageways that cross the areas should be stabilized. Yields of all the crops grown in the county are high. (Capability unit I-1; Silty to clayey woodland site.)

Monona silt loam, 1 to 3 percent slopes (MnA).—This soil is on very gently sloping ridgetops. It is easily tilled, is high in organic matter, and produces well. It needs management, however, that will help control loss of soil and water. (Capability unit IIe-1; Silty to clayey woodland site.)

Monona silt loam, 3 to 7 percent slopes (MnB).—This soil has a profile similar to the one described for the Monona series but has thinner horizons. It is on gentle slopes and ridges. It is easily tilled and takes in and releases moisture well. In areas where runoff and erosion are controlled, yields are very satisfactory. (Capability unit IIe-1; Silty to clayey woodland site.)

Monona silt loam, 3 to 7 percent slopes, eroded (MnB2).—This soil has a profile similar to the one described for the Monona series. Because of soil loss from erosion, however, the surface horizon is only 6 to 8 inches thick.

As this soil is on gentle slopes and ridges, it needs management that will help control loss of water and soil. (Capability unit IIe–1; Silty to clayey woodland site.)

Monona silt loam, 7 to 12 percent slopes (MnC).—The profile of this soil is similar to that described for the Monona series, but it has thinner horizons and less development. This soil occurs on strongly sloping areas, usually below the ridgetops.

This soil will produce well and is easily tilled. If soil and water losses are to be kept low, it must be farmed with care. (Capability unit IIIe–1; Silty to clayey woodland site.)

Monona silt loam, 7 to 12 percent slopes, eroded (MnC2).—The plow layer of this soil has been made lighter in color by the loss of organic matter and the addition of subsoil material through tillage. Crop yields of this soil have decreased because of its reduced fertility, organic-matter content, and moisture-intake rate. (Capability unit IIIe–1; Silty to clayey woodland site.)

Monona-Crofton silt loams, 12 to 18 percent slopes (MCD).—The soils of this complex are on the lower parts of moderately steep to steep slopes and on the few, uncultivated areas of the Monona and Crofton soils of this slope range. The thin Crofton soils occupy the shoulders of slopes and points of ridges and make up 20 to 40 percent of the complex. They are generally calcareous at or near the surface. The Monona soils occupy the smooth parts of the slopes or the concave slopes along drains.

Because of the difference in the surface color of the soil or the vigor of growing crops, many areas that have been or are now cultivated appear spotted. Yields are reduced in areas where the organic matter is low and the substratum is at or near the surface. Typical Crofton soils are described under the Crofton series. (Capability unit IVe–1; Silty to clayey woodland site.)

Monona-Crofton silt loams, 12 to 18 percent slopes, eroded (MCD3).—This complex of soils occurs on moderately steep to steep slopes (fig. 14). The areas have been cultivated, and erosion has removed much of the surface layer. The Crofton soils make up from 40 to 60 percent of the total area. The soils are relatively unproductive if used for cultivated crops. Soil losses caused by both sheet and gully erosion are excessive. A cover of close-growing crops is needed on the soils of this complex most of the time to reduce erosion. Typical Crofton soils are described under the Crofton series. (Capability unit IVe–8; Silty to clayey woodland site.)

***Figure 14.*—Monona-Crofton silt loams on moderately steep slopes.**

Moody Series

The Moody series consists of deep, dark, well-drained soils. These soils developed in the gently sloping to rolling loess uplands west of Bell Creek. They are moderately fine textured. In this county the solum is generally noncalcareous.

The surface layer is very dark brown silty clay loam, 5 to 10 inches thick. It has granular structure. The subsoil is dark-brown silty clay loam that has the finest texture in the upper part. It ranges from 20 to 30 inches in thickness and has a subangular blocky structure. The substratum is light yellowish-brown light silty clay loam or silt loam. It has weak, coarse, prismatic structure, and in many areas it is mottled. Commonly the upper part of the substratum is calcareous and the lower part contains concretions.

The Moody soils are associated with the Belfore soils, which are on the flats and have a finer textured subsoil. They are also associated with the Nora soils, which are on similar or steeper slopes. The Nora soils are calcareous higher in the profile and are somewhat coarser textured than the Moody soils.

Most areas of Moody soils are cultivated and are productive. These soils can be tilled within a rather wide range in moisture, and they take in and hold moisture well. They are rather high in organic matter and potassium. Although they are not deficient in nitrogen and phosphorus, except in eroded areas, they need additions of these fertilizers for maximum yields. Conservation practices are needed for erosion control.

The native vegetation was tall prairie grass. In this county the Moody soils are mapped only in undifferentiated units with the Marshall and Nora soils.

Moody and Marshall soils, 3 to 7 percent slopes (MMB).—The soils of this mapping unit occur on gentle slopes and ridgetops west of Bell Creek. Most areas are cultivated, but management has been such that the dark surface layer is still in place. The Moody soils make up 75 percent of the mapping unit, and Marshall soils, 25 percent. These soils have profiles similar to those described for their respective series.

These soils produce high yields of all crops adapted to the county. Erosion control and moisture conservation on the steeper slopes increase yields. Maintaining fertility is the main requirement. (Capability unit IIe–1; Silty to clayey woodland site.)

Moody and Marshall soils, 3 to 7 percent slopes, eroded (MMB2).—The soils of this mapping unit occur west of Bell Creek on gentle slopes and ridgetops. They have been cultivated and have lost a part of the original surface layer through erosion. The Moody soils make up 75 percent of the mapping unit, and the Marshall soils, 25 percent. The soils in this unit have profiles that are similar to those described for their respective series, except that they have lost a part of the original surface layer.

Erosion control is needed to reduce soil and moisture losses and to help maintain high crop yields. Maintaining fertility is also a problem. (Capability unit IIe–1; Silty to clayey woodland site.)

Moody and Marshall soils, 7 to 12 percent slopes (MMC).—The soils of this mapping unit are on moderate slopes west of Bell Creek. Most areas are in grass or have been so cultivated that erosion is only slight. The Moody soils make up 75 percent of the mapping unit, and the Marshall soils, 25 percent. The soils in this mapping unit have profiles very similar to those described for their respective series.

Erosion control practices are needed for keeping soil and water losses low and for maintaining fertility and high yields of adapted crops. (Capability unit IIIe–1; Silty to clayey woodland site.)

Moody and Marshall soils, 7 to 12 percent slopes, eroded (MMC2).—The soils of this mapping unit are west of Bell Creek on the moderate slopes where an appreciable amount of erosion has occurred. The soils are cultivated. As a result of erosion, the dark surface layer has been thinned and the lighter colored subsoil shows on the ridge points and slope breaks. The Moody soils make up about 70 percent of the mapping unit, the Marshall soils, 20 percent, and other soils, about 10 percent.

Because of the loss of surface soil and moderately steep slopes, the soils in this mapping unit need more careful management for controlling erosion and maintaining fertility than the other areas of the Moody and Marshall soils. (Capability unit IIIe–1; Silty to clayey woodland site.)

Nora Series

In the Nora series are deep, well-drained soils that developed on rolling to steep slopes in the loess uplands of the western two-thirds of Washington County. These soils are medium to moderately fine textured and are calcareous in the lower B horizon or substratum.

Nora soils have a very dark grayish-brown to dark brown silt loam to light silty clay loam surface layer. This layer has granular structure and is 4 to 8 inches thick. In some cultivated areas on steep or eroded slopes, material from the B horizon is plowed into this layer. The subsoil is dark grayish-brown to brown, light silty clay loam, 10 to 20 inches thick. The structure is compound—weak, coarse, prismatic to weak, fine and medium, subangular blocky (fig. 15). A few mottles are in the lower part of the subsoil in places. Also, the subsoil is calcareous in places. The substratum is yellowish- to olive-brown, calcareous silt loam.

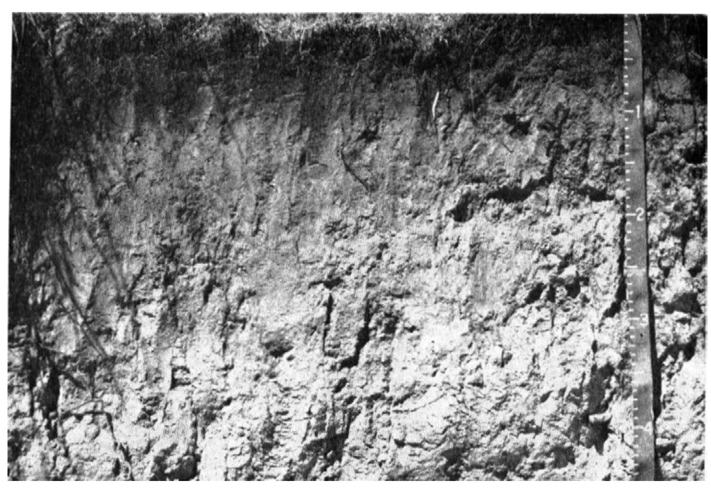

***Figure 15.*—Profile of a Nora soil.**

Nora soils are mapped in undifferentiated units with the Crofton, Marshall, and Moody soils and are most extensive on eroded slopes. The Nora soils mapped with the Crofton soils are on the concave or lower parts of the slope, and show more profile development and less erosion than the Crofton. The Nora soils mapped with the Marshall, as well as the Nora soils mapped with the Moody soils, are the less developed and more severely eroded soils in the undifferentiated units.

Nora soils are easily tilled within a relatively wide range in moisture content. If the surface is protected, they take in and hold moisture well. They were fertile before erosion removed part or all of the original surface layer. Although suited to most crops grown in the county, the Nora soils need additional organic matter and nitrogen and phosphate fertilizers for satisfactory crop production. Excessive amounts of lime may reduce the availability of phosphorus. In cultivated areas soil and moisture losses must be controlled. The native vegetation was tall prairie grass.

Nora and Crofton soils, 7 to 12 percent slopes, severely eroded (NCC3).—The soils of this mapping unit have moderately steep slopes. They are cultivated, and much or all of the original surface layer has been removed by erosion. The Crofton soils on the thin points and shoulders of ridges make up 40 percent of this undifferentiated unit, and those on small areas along the drains make up less than 10 percent. The Nora soils make up the rest. These Nora and Crofton soils are associated with areas of Moody and Marshall soils.

The loss of organic matter and the reduced soil fertility have lowered the rate of moisture intake and increased the erosion hazard. (Capability unit IIIe–8; Silty to clayey woodland site.)

Nora and Crofton soils, 12 to 18 percent slopes, severely eroded (NCD3).—These steeply sloping soils are under cultivation or have been cultivated. They have lost most or all of their original surface layer. This undifferentiated unit is similar to the Nora and Crofton soils on 7 to 12 percent slopes, but it consists of about half Nora soils and half Crofton soils. It is associated with areas of Moody and Marshall soils on the flatter slopes.

Erosion is excessive unless close-growing crops are used most of the time. (Capability unit IVe–8; Silty to clayey woodland site.)

Nora and Marshall soils, 7 to 12 percent slopes, severely eroded (NC3).—These soils occur in the central part of the county on moderately steep slopes, below the areas of Sharpsburg and Marshall soils that are on ridgetops. They have lost most or all of their original surface layer. About 60 percent of this undifferentiated unit consists of Nora soils, and 40 percent of Marshall soils.

Erosion control and the use of close-growing crops are necessary if these soils are to be kept in cultivation. (Capability unit IIIe–8; Silty to clayey woodland site.)

Nora and Marshall soils, 12 to 18 percent slopes, eroded (ND2).—This mapping unit occurs on steep slopes in the central part of the county. In general, the soils of this unit are only moderately eroded. The Nora soils make up about 60 percent of the unit, and the Marshall soils, about 40 percent. In most areas the surface soil is dark colored, but in some areas light-colored spots are evident on ridge points.

Not all areas of these soils are cultivated. Tilled areas have been protected to some extent from erosion. Erosion control practices and crops that provide cover much of the time are needed. (Capability unit IVe–1; Silty to clayey woodland site.)

Nora and Marshall soils, 12 to 18 percent slopes, severely eroded (ND3).—The soils of this mapping unit are on steep slopes in the central part of the county. They are or have been cultivated and have lost most of the dark surface layer. Light-colored parent material is exposed on the ridge points and shoulders of slopes. The Nora soils make up about 60 percent of the mapping unit, the Marshall soils, 25 percent, and other soils, 15 percent.

Unless erosion control practices are used to reduce runoff and row crops are planted in the cropping system only 1 year in 5, soil and moisture losses are excessive. (Capability unit IVe–8; Silty to clayey woodland site.)

Nora and Moody soils, 12 to 18 percent slopes, eroded (NMD2).—The soils in this mapping unit are on steep, eroded, cultivated slopes of the bluffs along the Elkhorn River. About 70 percent of the mapping unit consists of Nora soils that have lime at or near the surface, and 30 percent consists of Moody soils.

Because these soils have lost most of the original surface layer, the content of organic matter is low, and the water intake is reduced. Also, fewer crops can be successfully grown, and yields are lower. If cultivation is continued, erosion control practices are necessary. (Capability unit IVe–1; Silty to clayey woodland site.)

Onawa Series

The Onawa series consists of nearly level, deep, light-colored soils that are somewhat poorly drained. These soils have developed in recently deposited alluvium on the low bottom lands of the Missouri River. They have a fine to moderately fine textured surface layer and a silty to loamy subsoil. They are generally calcareous from the surface to the water table, which is at a depth of 2 to 6 feet.

The Onawa soils have a grayish-brown surface layer, 10 to 20 inches thick, that is granular in structure. The subsoil is a transitional horizon that is moderately fine to medium textured and somewhat lighter colored than the surface layer. The substratum is medium textured, is light grayish brown, and in many areas is stratified with finer and coarser material. In places it is mottled.

The Onawa soils are associated with the Albaton, Carr, and Haynie soils. They are similar to the Albaton soils but have a coarser textured subsoil and substratum. They have a finer textured subsoil and substratum than the Haynie and Carr soils.

These soils are moderately productive but can be tilled only within a rather narrow range in moisture. Corn, sorghum, wheat, and alfalfa are adapted to these soils. Because of the high content of lime in these soils, legumes start easily. Available phosphorus is lacking in places. Organic matter and nitrogen are both below the amounts needed for maximum production. The native vegetation consisted of trees and grass.

Onawa clay (Ou).—This soil has a profile similar to the one described for the Onawa series. The slopes range from 0 to 1 percent. In cultivated areas nitrogen and phosphate fertilizers are needed for maximum production. Floods have been a problem, and wetness affects the timing of farming operations. (Capability unit IIIw-1; Moderately wet woodland site.)

Onawa and Haynie silty clay loams (OH).—The soils in this mapping unit are similar to those described for the Onawa and Haynie series except that both soils have a moderately fine textured surface layer. Slopes range from 0 to 1 percent. These soils are somewhat poorly drained. If moisture is normal, they are quite productive. Nitrogen and phosphate are needed for maximum yields. (Capability unit IIw-4; Moderately wet woodland site.)

Rauville Series

The Rauville series consists of very poorly drained alluvial soils that occur in swales and channels in the bottom lands of the Elkhorn and Missouri Rivers. Mapped areas are quite variable in texture but are dominantly medium to fine textured.

The Rauville soils have a dark, granular surface layer. In many areas the subsoil is gleyed or mottled, and shades of gray and brown are common. The subsoil is granular and, in texture is similar to the surface layer. The substratum is 1 to 3 feet below the surface and is generally within the fluctuating water table. Its layers range from sand to clay and, as a rule, are gleyed or mottled. These soils are usually weakly to moderately calcareous above the water table.

The Rauville soils are wetter and have a higher water table than the clayey Albaton or Luton soils and the loamy Haynie or Leshara soils. The Rauville soils are too wet for cultivation but produce trees and coarse grass in abundance. In areas managed for pasture, they produce fair grazing. A greater variety of grasses can be grown in drained areas.

Rauville soils (Ra).—The surface layers of the soils in this mapping unit range from medium to fine, but some areas of wet sandy soils are included. Rauville soils have dark-colored surface layers and, in places, are dark below the present water table. Layers below the surface layer are gleyed and mottled, where not masked by dark-colored organic matter. The slopes range from 0 to 1 percent. Rauville soils, as well as the included areas of other soils, are too wet for cultivation and have a water table at or near the surface some time during the year. (Capability unit Vw-1: Wet woodland site.)

Riverwash

Riverwash (Rw).—The bars and islands along the Elkhorn and Missouri Rivers make up this land type. These areas consist of recent deposits of poorly sorted sand, silt, and clay that are frequently flooded. Some areas have been in place for some time and are covered by coarse grass and shrubs. The more recent deposits have little vegetation. The profile varies greatly from place to place. Some areas of this land type have been included with the adjacent Sarpy, Carr, or other soils on the low bottom lands that are used for pasture. (Capability unit VIIIe-1; not stable enough to be designated as a woodland site.)

Salix Series

The Salix series are nearly level, deep, medium-textured, well-drained soils that developed in old alluvium on the high bottom lands along the Missouri River. They are on the natural levee near the edge of the low bottom lands. The profile of the Salix series has horizons that are more distinct than those of other bottom-land soils. The depth to the water table ranges from 5 to 15 feet.

The surface layer is very dark grayish-brown silt loam, 10 to 15 inches thick. It has granular structure. The subsoil is brownish silt loam with prismatic structure and, like the surface layer, is leached of lime. The substratum is pale-brown silt loam or loam. It is calcareous and has weak, prismatic structure.

The Salix soils are associated with and are similar to the Volin soils, which have less profile development. They are associated to a lesser extent with the Leshara and McPaul, which also have less profile development.

The Salix soils are among the most productive in the county. They have excellent moisture relationships, have almost no conservation problems, and are high in fertility. In some areas they need nitrogen and some phosphate for maximum yields. The native vegetation was tall prairie grass.

In this county the Salix soils were mapped only as an undifferentiated unit with the Volin soils.

Salix and Volin silt loams (Sv).—The soils described for the Salix and Volin series are typical of the soils in this mapping unit. Both soils occur as an undifferentiated unit within one area and as individual soils in widely separated areas along the high bottom lands. Slopes range from 0 to 1 percent. The Salix soils occur mainly north of Blair, and the Volin soils, mainly east of Fort Calhoun. The areas mapped as undifferentiated units are about 40 percent Salix soils, and 60 percent Volin. (Capability unit I-1; Silty to clayey woodland site.)

Sarpy Series

The Sarpy series consists of immature, coarse-textured soils that developed in recent sandy alluvial deposits. These soils occur on the nearly level to hummocky, low bottom lands of the Missouri and Elkhorn Rivers. They are imperfectly drained and have a water table that is from 2 to 10 feet below the surface. Because of their coarse texture, they are very permeable.

The surface layer is dark grayish-brown to grayish-brown loam to loamy sand. It has weak, granular structure and is from 6 to 12 inches thick. The subsoil is grayish-brown loamy fine sand that is loose and single grained. The substratum consists of stratified coarse sand and fine sand; gravel or fine-textured material is not uncommon. These soils are neutral to alkaline, and in many places are calcareous throughout the profile.

The Sarpy soils are on the same level as the associated Carr, Haynie, Onawa, and Albaton soils but are coarser textured than these soils.

Because of their coarse texture and low content of organic matter, the Sarpy soils produce low to moderate yields. Grass, alfalfa, and small grain yield better than corn or soybeans, as these soils have a low moisture-holding capacity and low fertility. They are easily tilled, however, within a wide moisture range. Trees and grass were the native vegetation.

Sarpy loamy fine sand (Sg).—This soil has a loamy fine sand surface layer that is lighter colored than the surface layer of Sarpy loam. The subsoil is slightly lighter colored than the surface layer and has about the same texture. The slopes range from 0 to 4 percent.

A small acreage of this soil is associated with the Cass and Leshara soils along the Elkhorn River. This soil is coarser textured, has more channels and hummocks, and is at a lower level than the Cass and Leshara soils. It is lighter colored and coarser textured, however, and has a more irregular surface than the Carr, Haynie, Onawa, and Albaton soils that are associated with this soil along the Missouri River. It is also less productive and more susceptible to wind erosion.

This soil is low in fertility and water-holding capacity. Wind erosion is severe where the surface is unprotected. (Capability unit IIIw-5; Moderately wet woodland site.)

Sarpy loam (Sl).—This soil has a profile similar to that described for the Sarpy series. It is associated with the same soils as Sarpy loamy fine sand. The surface layer is a moderately dark loam, but areas of sandy loam are included. The slopes range from 0 to 1 percent.

This soil is moderately productive and is easily tilled. It is somewhat droughty, however, and the surface layer must be protected. (Capability unit IIw-4; Moderately wet woodland site.)

Sharpsburg Series

The Sharpsburg series consists of well-drained soils of the uplands and a small area of soils on the terraces. These soils developed in loess and have a moderate degree of horizonation. They occur on the level uplands, on Bell Creek terraces, and on adjacent slopes of as much as 12 percent. They are in the central part of the county, east of Bell Creek and west of the Missouri River.

The typical profile on the nearly level to gentle slopes has a surface layer of very dark brown, light silty clay loam. This layer has granular structure and is 12 to 18 inches thick (fig. 16). The subsoil is dark-brown, heavy silty clay loam, 20 to 30 inches thick. It has subangular blocky structure and is lighter colored and finer textured than the surface layer. The substratum is yellowish-brown, slightly mottled, light silty clay loam. The Sharpsburg soils are noncalcareous, and their solum is slightly acid. The substratum is neutral but becomes alkaline below 5 feet.

The Sharpsburg soils are associated with the Marshall and Nora soils. On all but the level uplands and wide ridgetops, the Sharpsburg and Marshall soils are mapped as undifferentiated units. The Sharpsburg soils are on the more level and smooth parts of the landscape, and the Marshall soils are on the steeper, more irregular parts.

The Sharpsburg are among the most suitable soils for agriculture in the county. They are easily tilled and take in moisture readily and hold it for plant use. They are quite high in organic matter, but most crops need additional nitrogen for maximum production. The use of lime and phosphate improves legume stands; however, potassium is adequate for all but special crops. Conservation practices are needed to reduce erosion on the sloping areas. Tall prairie grass was the native vegetation.

Figure 16.—**Profile of Sharpsburg silty clay loam. The Sharpsburg soils are deep, are moderately fine textured, and have granular to blocky structure.**

Sharpsburg silty clay loam, 0 to 1 percent slopes (Sh).—This soil has a profile like the one described for the Sharpsburg series. It is on the nearly level uplands and on the level parts of terraces along Bell Creek. It is well drained but includes a few imperfectly drained spots that are too small to be mapped separately. Runoff and erosion are at a minimum, but conservation practices that protect the surface soil are beneficial. (Capability unit I-1; Silty to clayey woodland site.)

Sharpsburg and Marshall soils, 1 to 3 percent slopes (SMA).—The soils of this mapping unit occur on gently sloping ridgetops and on the gentle slopes around the edge of the level uplands in the central part of the county. In most areas the Sharpsburg soils make up about 70 percent of the mapping unit, and the Marshall soils, about 30 percent.

These soils are productive. Their need for fertilizer is discussed under the Sharpsburg series. Conservation practices are needed to protect these soils from runoff and erosion. (Capability unit IIe–1; Silty to clayey woodland site.)

Sharpsburg and Marshall soils, 3 to 7 percent slopes (SMB).—The soils of this mapping unit occur on narrow ridgetops and on moderate slopes along drainageways and below the level uplands. They are in the central part of the county. The Sharpsburg and Marshall soils each make up about 45 percent of this undifferentiated unit. Inclusions of Judson and Nora soils make up the rest.

The profiles of the Sharpsburg and Marshall soils, 3 to 7 percent slopes, are similar to those described for their respective series but have somewhat thinner horizons. Soil and fertility losses are more difficult to control on these soils than on the Sharpsburg and Marshall soils on 1 to 3 percent slopes, and more intensive conservation practices are needed. (Capability unit IIe–1; Silty to clayey woodland site.)

Sharpsburg and Marshall soils, 3 to 7 percent slopes, eroded (SMB2).—The soils of this mapping unit are on narrow ridges and valley slopes where erosion has removed much of the original surface layer. These areas are in the central part of the county. The Sharpsburg soils make up about 45 percent of the unit, and the Marshall soils, about 45 percent. The Nora and Judson soils make up the rest.

The soils of this unit are similar to the Sharpsburg and Marshall soils, 3 to 7 percent slopes, but their surface layer is 6 to 10 inches thick and, in places, some of the subsoil has been mixed with the plow layer by tillage. In addition, their fertility is lower and erosion is more difficult to control than on the similar uneroded Sharpsburg and Marshall soils. Applications of fertilizer and conservation practices are needed. (Capability unit IIe–1; Silty to clayey woodland site.)

Sharpsburg and Marshall soils, 7 to 12 percent slopes (SMC).—The soils in this mapping unit usually occur on the lower slopes between the ridgetops and drainageways in the central part of the county. The Sharpsburg and Marshall soils each make up about 40 percent of the unit. Inclusions of Judson and Nora soils make up the rest. The profiles of the Sharpsburg and Marshall soils have thinner horizons than those described for their respective series. These soils are less fertile than the Sharpsburg and Marshall soils on 1 to 3 percent slopes, and runoff and erosion are more difficult to control. (Capability unit IIIe–1; Silty to clayey woodland site.)

Sharpsburg and Marshall soils, 7 to 12 percent slopes, eroded (SMC2).—The soils in this mapping unit occur on the slopes between the ridgetops and drainageways in the central part of the county. The Sharpsburg soils make up about 40 percent of the area, the Marshall soils, 40 percent, and Nora and Judson soils, about 20 percent.

The soils in this mapping unit are similar to Sharpsburg and Marshall soils, 7 to 12 percent slopes, except that their surface layer is 4 to 8 inches thick. In many areas, the subsoil material has been mixed with the plow layer. Applications of fertilizer and conservation practices are more necessary on these soils than on the less eroded soils. (Capability unit IIIe–1; Silty to clayey woodland site.)

Spoil Banks

Spoil Banks (S).—This land type is made up of areas that have been disturbed by the construction of large drainage ditches across the bottom lands or by the removal of sand, gravel, and rock. The slopes range from gently sloping to steep. Some areas have been smoothed and vegetated for erosion control. None of these areas have been undisturbed long enough for soils to develop.

Steinauer Series

The Steinauer series is made up of thin, immature soils that developed from calcareous, glacial till. These soils occur on the steep slopes along streams in the eastern part of the uplands and in a few places on the Elkhorn River breaks.

The surface layer is calcareous, grayish-brown clay loam, 4 to 8 inches thick. It is granular and friable. A thin transitional layer separates the surface layer from the substratum. This layer is similar to the surface layer in texture but is intermediate in color and structure. The substratum is little-weathered till consisting of olive-gray, blocky clay loam. It is mottled with yellowish brown and gray and is strongly calcareous.

These soils are associated with the Burchard soils and are below the Monona soils on the slopes.

Because of their steep slopes, the Steinauer soils are usually not cultivated. The moderately fine texture of the surface layer makes cultivation difficult. Also, moisture intake is slow. The thin surface layer is not well supplied with organic matter and available plant nutrients. On the steeper slopes the native vegetation was tall and mid prairie grasses and trees.

Steinauer soils, 12 to 18 percent slopes, eroded (StD2).—The profile of Steinauer soils is like that described for the Steinauer series, except that the surface layer has been eroded on the convex parts of slopes. In areas that have been thinned by erosion, the surface layer has finer texture, lighter color, and less organic matter.

These soils should be kept in permanent vegetation. (Capability unit VIe–1; Silty to clayey woodland site.)

Volin Series

The Volin soils are nearly level, dark, deep, silty, and loamy. They are well to moderately well drained and have little horizonation. They developed in stream-deposited sediment on the high parts of the Missouri River bottom lands.

The surface layer is very dark gray to grayish-brown, granular silt loam, 12 to 18 inches thick. A transitional layer separates the surface layer from the substratum. This layer is usually calcareous. It is about the same texture as the surface layer but is lighter colored. The grayish-brown substratum is loam to silt loam in texture but, in places, is stratified with finer and coarser layers, especially in the lower part. It is weakly granular and calcareous. The water table is from 5 to 15 feet below the surface.

The Volin soils are associated with the Salix soils. In texture they are similar to these soils, but they are not so well drained, are less leached, and show less profile development. The Volin soils are better drained than the

Leshara soils and occur at higher levels. They are associated with the McPaul soils in places. They lack the recent light-colored deposits characteristic of these soils.

The Volin soils are among the most productive in the county. They are nearly level, are easily tilled, and take in and store moisture well. They are very little affected by water or wind erosion. They have a good supply of organic matter but need nitrogen and phosphate for maximum production. The native vegetation consists of trees and grass.

In this county the Volin soils are mapped only in an undifferentiated unit with the Salix soils.

Use and Management of Soils

In this section are discussed capability groups of soils, management of soils by capability units, predicted acre yields under two levels of management, general management of cropland, uses of the soils for pasture, woodland, and wildlife, and engineering uses of soils.

Capability Groups of Soils

The capability classification is a grouping that shows, in a general way, how suitable soils are for most kinds of farming. It is a practical grouping based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment.

In this system all the kinds of soil are grouped at three levels, the capability class, subclass, and unit. The eight capability classes in the broadest grouping are designated by Roman numerals I through VIII. In class I are the soils that have few limitations, the widest range of use, and the least risk of damage when they are used. The soils in the other classes have progressively greater natural limitations. In class VIII are soils and landforms so rough, shallow, or otherwise limited that they do not produce worthwhile yields of crops, forage, or wood products. There are no class VII soils in this county.

The subclasses indicate major kinds of limitations within the classes. Within most of the classes there can be up to four subclasses. The subclass is indicated 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* means that water in or on the soil will interfere 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 country, indicates that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few or no limitations. Class V can contain, at the most, only subclasses *w*, *s*, and *c*, because the soils in it have little or no susceptibility to erosion but have other limitations that limit their use largely to pasture, range, woodland, or wildlife.

Within the subclasses are the capability units, groups of soils 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 identified by numbers assigned locally, for example, IIe-1 or IIIe-1.

Soils are classified in capability classes, subclasses, and units in accordance with the degree and kind of their permanent limitations; but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soil; and without consideration of possible but unlikely major reclamation projects.

The eight classes in the capability system and the subclasses and units in this county are described in the list that follows.

Class I.—Soils that have a few limitations that restrict their use. These soils are suitable for intensive cultivation over long periods and do not require special practices other than those used for good farming. (No subclasses.)
- Capability unit I-1.—Deep, nearly level, easily worked soils.

Class II.—Soils that have some limitations that reduce the choice of plants or require moderate conservation practices. They are suitable for tilled crops, pasture, or woodland.
- Subclass IIe.—Soils subject to moderate erosion if they are not protected.
  - Capability unit IIe-1.—Deep, gently sloping, easily worked soils.
  - Capability unit IIe-3.—Deep, nearly level sandy soils.
- Subclass IIw.—Soils that have moderate limitations because of excess water.
  - Capability unit IIw-3.—Deep soils of the bottom lands that are occasionally flooded.
  - Capability unit IIw-4.—Deep, nearly level, easily worked soils of the bottom lands that are occasionally wet because of a high water table.

Class III.—Soils that have severe limitations that reduce the choice of plants, or require special conservation practices, or both. These soils are suitable for tilled crops, pasture, woodland, or wildlife.
- Subclass IIIe.—Soils subject to severe erosion if they are cultivated and not protected.
  - Capability unit IIIe-1.—Deep, easily worked soils on moderate slopes; erosion is slight to moderate.
  - Capability unit IIIe-8.—Deep, moderately sloping, severely eroded soils.
- Subclass IIIw.—Soils that have severe limitations because of excess water.
  - Capability unit IIIw-1.—Imperfectly drained, fine-textured (heavy clay), bottom-land soils.
  - Capability unit IIIw-2.—Imperfectly drained, bottom-land soils that have a silty surface layer and a clay subsoil.
  - Capability unit IIIw-5.—Very sandy, bottom-land soils that are imperfectly drained because of a high water table.
  - Capability unit IIIw-6.—Imperfectly drained, moderately sandy soils.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both. They are suited to tilled crops, but need intensive management. They are also suited to pasture, woodland, or wildlife.

Subclass IVe.—Soils subject to very severe erosion if they are cultivated and not protected.

Capability unit IVe-1.—Deep, medium to moderately fine textured soils on moderately steep slopes.

Capability unit IVe-8.—Deep, medium to moderately fine textured soils on moderately steep slopes, severely eroded.

Class V.—Soils not likely to erode that have other limitations, impractical to remove without major reclamation, that limit their use largely to pasture or range, woodland, or wildlife food and cover.

Subclass Vw.—Soils too wet for cultivation; drainage or protection not feasible.

Capability unit Vw-1.—Very wet bottom lands.

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

Subclass VIe.—Soils severely limited, chiefly by risk of erosion if protective cover is not maintained.

Capability unit VIe-1.—Deep, silty soils on moderately steep to steep slopes; erosion may be severe.

Capability unit VIe-8.—Deep, silty soils on moderately steep to steep slopes, severely eroded.

Class VII.—Soils that have very severe limitations that make them unsuitable for cultivation without major reclamation, and that restrict their use largely to grazing, woodland, or wildlife. (No class VII soils in the county.)

Class VIII.—Soils and landforms not suitable for commercial production of crops, grasses, or woody plants.

Subclass VIIIe.—Unstable soil materials.

Capability unit VIIIe-1.—Gullied land and riverwash.

Management of soils by capability units

In this section the soils of Washington County are grouped in capability units. The soils in each unit are described and suggestions for use and management are given.

CAPABILITY UNIT I-1

The soils in this unit are deep, nearly level, and easily worked. They take in, store, and give up water readily to crops. In this unit are medium and moderately fine textured, well-drained soils on the uplands, benches, and bottom lands.

Minor flooding may occur on the bottom-land soils, but it is not serious. Erosion is not a problem on the soils of this unit. If the soils are well managed, yields are high. The soils in this unit are—

Cass loam.
Judson silt loam, 1 to 3 percent slopes.
Kennebec silt loam.
Monona silt loam, 0 to 1 percent slopes.
Salix and Volin silt loams.
Sharpsburg silty clay loam, 0 to 1 percent slopes.

The soils in this unit are among the best in the county (fig. 17). They are suited to all crops commonly grown in the county. A cropping system in which row crops, alfalfa, and small grain are grown helps to maintain

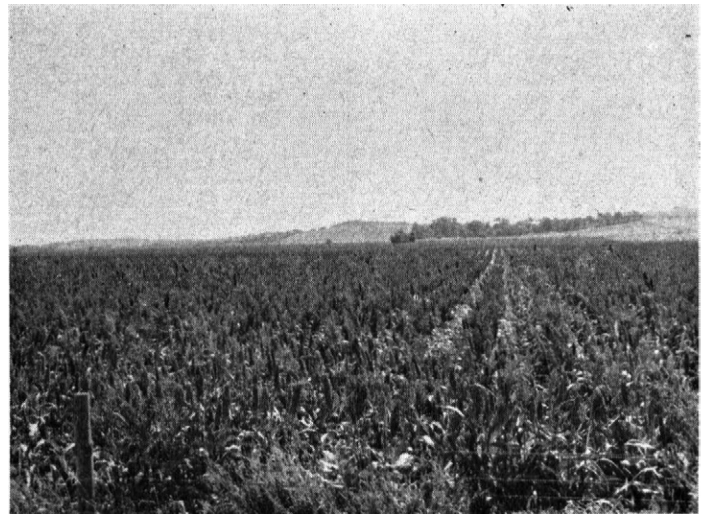

Figure 17.—Monona silt loam, 0 to 1 percent slopes, on the terrace of the Missouri river.

fertility and soil tilth and to control disease and insects. Legumes and grasses used in rotations may be advantageous to livestock farmers.

Crop residue and barnyard manure should be used to help maintain fertility and tilth. Needed amounts of lime, phosphate, and nitrogen should be determined by soil tests.

CAPABILITY UNIT IIe-1

This unit consists of deep, gently sloping, easily worked, medium and moderately fine textured soils on the uplands and terraces. The slopes range from 1 to 7 percent, and water erosion is slight to moderate. The soils absorb, store, and readily give up water for crops.

In cultivated areas water erosion is the chief hazard (fig. 18), and maintaining fertility is a major problem. The soils in this unit are—

Belfore silty clay loam.
Judson silt loam, 3 to 7 percent slopes.
Monona silt loam, 1 to 3 percent slopes.
Monona silt loam, 3 to 7 percent slopes.
Monona silt loam, 3 to 7 percent slopes, eroded.
Moody and Marshall soils, 3 to 7 percent slopes.

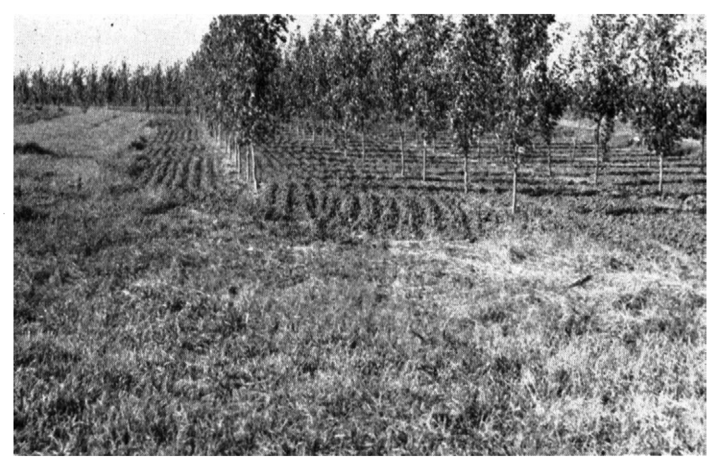

Figure 18.—Nursery trees on contour between terraces on Sharpsburg and Marshall soils, 3 to 7 percent slopes.

Moody and Marshall soils, 3 to 7 percent slopes, eroded.
Sharpsburg and Marshall soils, 1 to 3 percent slopes.
Sharpsburg and Marshall soils, 3 to 7 percent slopes.
Sharpsburg and Marshall soils, 3 to 7 percent slopes, eroded.

The soils in this unit are very productive and are easily managed; they are suited to all the crops commonly grown in the county. The use of crop rotations that include legumes and grass, the return of crop residue to the soil, and the use of barnyard manure will help maintain a high level of fertility and good tilth. If suited to the farm plan, a grass and legume should be grown every 8 to 13 years and left 2 to 4 years. Erosion can be more easily controlled, fertility maintained, and tilth improved if row crops are grown no more than 3 years in 5. Diseases and insects are also easier to control where the crops are rotated. Contour farming, with terraces and grassed waterways, is necessary for erosion control.

Nitrogen and phosphate fertilizers are needed, and also lime. Apply fertilizer in amounts indicated by soil tests.

CAPABILITY UNIT IIe-3

In this unit is a deep, nearly level sandy soil on bottom lands. The surface layer is dark-colored fine sandy loam, and the subsoil is a lighter colored sandy loam.

The sandy surface layer makes this soil easy to cultivate. If not protected by crop residue or growing crops, the soil is subject to wind erosion. It absorbs water well and readily releases it to plants. Because of its coarse texture, it is somewhat droughty. The soil in this unit is—

Cass fine sandy loam.

This soil is suited to all crops commonly grown in this county. A crop rotation that includes grass and legumes helps control erosion, maintain fertility, and improve soil tilth. Also, barnyard manure and crop residue returned to the soil help maintain soil tilth and a high level of fertility.

Some areas need lime and phosphate. Needs for these amendments, however, should be determined by soil tests. Nitrogen fertilizer or legumes plowed under for green manure are needed for continuous high production.

CAPABILITY UNIT IIw-3

The soils in this unit are deep, nearly level, and easily worked. They are subject to occasional flooding for short periods during heavy rains. Erosion is not a problem, but during some years deposits of silt may damage crops. The soils in this unit are—

Leshara soils, clayey substrata.
McPaul silt loam.

These soils are very productive and are suited to all crops commonly grown in the county. The use of crop rotations that include legumes and grass, the return of crop residue to the soil, and the use of barnyard manure help maintain good tilth and a high level of fertility. Diversion terraces are needed to protect these soils from flooding, and waterways are needed to carry away runoff.

Nitrogen and phosphate fertilizers, as well as lime, should be used. Determine the application of fertilizer needed by making soil tests.

CAPABILITY UNIT IIw-4

The soils in this unit are deep, nearly level, easily worked, and medium to moderately fine textured. They are on imperfectly drained bottom lands. Normally, the depth to the water table is between 2 and 5 feet. During wet seasons the high water table makes the soils wet and difficult to cultivate, but in dry years the water may be beneficial to crops. Wetness is the principal limitation of the soils in this unit; however, there are a few, small alkali areas on the Elkhorn River bottom lands. Open or tile drains may be needed to remove excess water. The soils in this unit are—

Haynie silt loam.
Lamoure-Colo silty clay loams.
Leshara silt loam.
Luton silty clay loam.
Luton silt loam, overwash.
Onawa and Haynie silty clay loams.
Sarpy loam.

These soils are suited to all crops commonly grown in the county. The few alkali areas in the southwestern corner of the county, which are inclusions in the Leshara soils, produce best if planted to alkali-resistant crops. If mixtures of grass and legumes are used in the cropping systems, they help maintain fertility and soil tilth. During wet periods, the high water table may thin or kill out stands of alfalfa.

The soils that occur on the Missouri River bottom lands are normally high in lime; those on the Elkhorn River bottom lands have only a moderate supply. Needed amounts of nitrogen and phosphate fertilizers should be determined by soil tests. Beneficial practices on these soils are the prevention of flooding and improvement of drainage through the use of tile drains and ditches, where needed (fig. 19).

Figure 19.—Tile being installed for drainage.

CAPABILITY UNIT IIIe-1

This unit consists of deep, medium-textured to moderately heavy soils on 7 to 12 percent slopes. Water erosion is slight to moderate. These soils absorb water readily and supply it readily to plants. The soils in this unit are—

Burchard clay loam, 7 to 12 percent slopes, eroded.
Monona silt loam, 7 to 12 percent slopes.
Monona silt loam, 7 to 12 percent slopes, eroded.
Moody and Marshall soils, 7 to 12 percent slopes.
Moody and Marshall soils, 7 to 12 percent slopes, eroded.
Sharpsburg and Marshall soils, 7 to 12 percent slopes.
Sharpsburg and Marshall soils, 7 to 12 percent slopes, eroded.

These soils are suited to all crops commonly grown in the county. When properly managed, they are productive and easily worked. Growing grass and legumes and using barnyard manure and crop residue help maintain fertility and improve soil tilth.

To control soil loss, limit the use of row crops on these soils. On the lesser slopes, use a cropping system that provides for 4 consecutive years of row crops in 8. On the steeper slopes, limit row crops to 2 years in 5 or 6.

Practices needed to conserve moisture and control erosion are contour farming, terracing, and construction of grass waterways. Stripcropping along with terracing may be used to reduce runoff and erosion (fig. 20). Tillage that leaves crop residue at or near the surface reduces runoff and increases the rate of water intake.

Nitrogen and phosphate fertilizers and lime should be used. Amounts of fertilizer and lime needed can be determined by soil tests.

CAPABILITY UNIT IIIe-8

This capability unit consists of deep, medium to moderately fine textured soils that have lost the dark-colored surface horizon through erosion. These severely eroded soils are low in fertility and are subject to severe water and gully erosion. Control of erosion and maintenance of fertility are the principal management problems. The soils in this unit are—

Crofton silt loam, 7 to 12 percent slopes, eroded.
Nora and Crofton soils, 7 to 12 percent slopes, severely eroded.
Nora and Marshall soils, 7 to 12 percent slopes, severely eroded.

These soils are suited to nearly all crops commonly grown in the county. Soybeans, however, are not suited. Barnyard manure should be used and crop residue should be returned to the soil to help maintain fertility and improve tilth. Because these soils are erodible, clean-tilled crops ordinarily should not follow each other. Crop rotations that include legumes and grasses help control erosion and reduce runoff. Severe erosion and high water loss can be controlled by contour farming that includes use of terraces and grass waterways.

Nitrogen and phosphate fertilizers should be used in amounts determined by soil tests. Lime may not be needed.

Figure 20.—**Terraced field with corn planted on contour and grassed waterway.**

Figure 21.—**If plowed when wet, Luton clay is difficult to prepare for a seedbed.**

CAPABILITY UNIT IIIw-1

This unit consists of deep, imperfectly drained soils of the bottom lands. These soils have slow surface drainage or a water table that ranges from 2 to 10 feet in depth. The surface layer is clay in texture and becomes cloddy if worked when too wet or too dry (fig. 21). During wet periods cultivation may be difficult, but during dry periods the water table may have a beneficial effect on crops. In years of normal rainfall, these soils are productive. The soils in this unit are—

Albaton clay.
Luton clay.
Luton and Leshara clays.
Onawa clay.

These soils are suited to all crops commonly grown in the county. Mixtures of grass and legumes in the cropping system help to maintain fertility and soil tilth. During wet periods a high water table may kill the alfalfa stand.

These soils are generally high in lime and low in available phosphorus. Nitrogen and phosphate fertilizer should be used in amounts shown by soil tests. Shallow surface drains can be used to remove excess surface water.

CAPABILITY UNIT IIIw-2

In this unit is an imperfectly drained soil of the bottom lands. This soil has a fine-textured subsoil and is occasionally flooded. It has a thick, moderately dark silt loam surface layer and a clay subsoil. The surface soil is easily worked and absorbs water readily, but the subsoil does not absorb water well and releases it slowly to plants.

The soil is fertile, but crops have sometimes been lost because of flooding. In wet years, this soil is occasionally too wet to cultivate. The soil in this unit is—

Albaton silt loam.

This soil is suited to all crops commonly grown in the county. Grass and legume mixtures help maintain fertility and soil tilth. During wet periods, a high water table may kill the stand of alfalfa. Shallow surface drains can be used to remove excess surface water.

This soil is generally high in lime and low in available phosphorus.

CAPABILITY UNIT IIIw-5

The soil in this unit has a very sandy surface soil and a subsoil that ranges from very sandy to fine sand. It occurs on the imperfectly drained bottom lands. Because of its sandy surface soil, this soil readily absorbs water. In places the depth to the high water table is between 2 and 10 feet. During dry years, the hazard of wind erosion is severe and the soil is droughty. In wet years, production may be limited by a high water table. The soil in this unit is—

Sarpy loamy fine sand.

This soil is suited to all crops commonly grown in the county. The use of crop residue and barnyard manure and the growing of legume mixtures will increase the content of organic matter and help maintain fertility and soil tilth. This soil is fairly productive, but potential fertility is low.

Areas of this soil on the Missouri River bottom lands are high in lime; those on the Elkhorn River bottom lands are not so well supplied. The soil is generally low in nitrogen and phosphorus. Fertilizer should be used in amounts determined by soil tests.

Conservation practices needed on this soil are use of cover crops, wind stripcropping, and shelterbelts. A system of tillage that leaves crop residue at or near the surface reduces the hazard of wind erosion. In wet years, ditches can be used to drain wet areas, although in dry years the underground water subirrigates the crops.

CAPABILITY UNIT IIIw-6

The soil in this unit is deep and has a moderately sandy surface soil. It is on the nearly level, imperfectly drained bottom lands. The imperfect drainage is caused by a high water table or by poor surface drainage. Productivity is fairly high.

The soil tends to be droughty and is subject to wind erosion. Wetness delays cultivation and lowers production in wet years. The soil in this unit is—

Carr fine sandy loam.

This soil is suited to all crops commonly grown in the county. The return of crop residue to the soil, the use of barnyard manure, and the growing of grass-and-legume mixtures will increase the organic-matter content and help maintain fertility and good soil tilth.

Conservation practices needed for controlling wind erosion are use of cover crops, stripcropping, and tillage that leaves crop residue at or near the surface. Wet areas may be drained by surface ditches and tile.

Figure 22.—Erosion is severe on moderately steep Nora and Crofton soils.

The fertility of this soil is generally low. The Carr soil is high in lime but low in nitrogen and phosphorus. Fertilizer should be used in amounts determined by soil tests.

CAPABILITY UNIT IVe-1

This unit consists of deep, medium to moderately fine textured soils that have slight to moderate erosion. Slopes are 12 to 18 percent. Generally, these soils are low in organic matter. They are friable and absorb water readily but are subject to severe sheet and gully erosion. The soils in this unit are—

Burchard clay loam, 12 to 18 percent slopes, eroded.
Monona-Crofton silt loams, 12 to 18 percent slopes.
Nora and Marshall soils, 12 to 18 percent slopes, eroded.
Nora and Moody soils, 12 to 18 percent slopes, eroded.

These soils are suited to nearly all crops commonly grown in the county. Soybeans, however, are not generally suited. Because of the high risk of erosion on these soils, row crops or clean-tilled crops should not follow each other in the cropping system. Good management includes the growing of grass or grass and legumes in the cropping system, the return of crop residue to the soil, and the use of barnyard manure. These practices help control erosion, maintain fertility, and improve soil tilth. Needed for conserving moisture and controlling erosion is contour farming that includes use of terraces and grass waterways. Tillage that leaves crop residue at or near the surface also helps reduce runoff and increase the rate of water intake.

Generally, these soils are high in lime but low in available nitrogen and phosphorus. Soil tests are needed to determine the amount of fertilizer needed.

CAPABILITY UNIT IVe–8

In this unit are deep, medium to moderately fine textured soils that have a severely eroded surface soil. The slopes are 12 to 18 percent. These soils are low in fertility and are subject to severe sheet and gully erosion (fig. 22).

The soils in this unit are—

Crofton silt loam, 12 to 18 percent slopes, eroded.
Monona-Crofton silt loams, 12 to 18 percent slopes, eroded.
Nora and Crofton soils, 12 to 18 percent slopes, severely eroded.
Nora and Marshall soils, 12 to 18 percent slopes, severely eroded.

Locally adapted crops may be grown on these soils. Because of the low fertility and the severely eroded surface soil, however, a grass or grass-and-legume mixture should be grown most of the time, crop residue returned to the soil, and barnyard manure applied. These practices furnish organic matter and help maintain fertility and soil tilth. Row crops should not follow row crops in the cropping system. Soybeans are not suited. The conservation practices required are terracing, contour farming, use of grass waterways, and gully control.

These soils are generally low in phosphorus and are low in nitrogen unless they have recently been planted to a legume. They are usually high in lime. The amount of lime and fertilizer needed can be determined by soil tests.

CAPABILITY UNIT Vw–1

This unit consists of deep, medium- to fine-textured soils on very wet bottom lands. Normally, the water table is at or very near the surface. Because of the high water table, these soils are unsuitable for cultivation. The soils in this unit are—

Rauville soils.

These soils are covered with willows, cattails, grasses, sedges, and other water-loving plants. They require no special management. During some seasons, these soils are so wet that grazing may have to be limited. They are an excellent habitat for wildlife; however, proper wildlife management is needed to produce game for good hunting.

CAPABILITY UNIT VIe–1

This unit consists of deep, medium to moderately fine textured soils that have a thin or severely eroded surface layer (fig. 23). Runoff is high, and sheet and gully erosion may be severe. The soils in this unit are—

Crofton silt loam, 18 to 30 percent slopes.
Steinauer soils, 12 to 18 percent slopes, eroded.

Most areas are now used for grass and trees—a use to which they are best suited. Small, isolated areas may be seeded or planted to trees and shrubs and managed for wildlife.

Cultivated areas should be converted to grass or woodland. A mixture of native grasses that include bluestem, switchgrass, and Indiangrass should be used on areas converted to grass. Special management is needed for introduced grasses.

Areas in native grass should be managed for maximum production, but adequate cover should be maintained for erosion control. Practices, such as proper stocking, deferred grazing, use of fertilizer for introduced grasses, and rotation grazing, should be followed. Terracing, gully-control structures, and seedings in waterways may be needed where water erosion has been severe. Dams for holding water for livestock or for recreational purposes can be built in some places along the drainageways of these soils.

Figure 23.—Landscape, showing cultivated Crofton silt loam, 18 to 30 percent slopes, that is better suited to grass.

CAPABILITY UNIT VIe-8

The soil in this unit is deep and medium textured and has a severely eroded surface layer. It is a loess soil that has slopes of more than 18 percent. Runoff is high, and sheet and gully erosion are severe. Since this soil is severely eroded, fertility and the content of organic matter are low. The soil in this unit is—

Crofton silt loam, 18 to 30 percent slopes, eroded.

This soil is best suited to grass and trees. Small, isolated areas may be seeded or planted for wildlife. Cultivated areas should be converted to grass or woodland. The types of grass chosen for these areas depend on the management practices that the farmer wants to use.

Erosion can be controlled by using introduced cool-season grasses and maintaining a high level of fertility by applying fertilizer. An alternative is the use of mixtures of adapted native grasses similar to those in the natural climax vegetation.

Management of grassed areas should be designed to obtain maximum production while maintaining an adequate cover for erosion control. Such management should include proper stocking, deferred grazing, use of fertilizer for introduced grasses, and rotation grazing. Gully-control structures, and seedings in waterways may be needed where water erosion has been severe.

Good sites for dams occur along the drainageways of this soil. The dams can be used to hold water for livestock or for recreational purposes.

CAPABILITY UNIT VIIIc-1

This unit consists of land types that are not suitable for production of crops or grass. The land types in this unit are—

Gullied land, Judson materials.
Riverwash.

Gullied land, Judson materials, consists of severely gullied areas in channels of the upland drainageways. In these areas the stream grade has been increased by straightening the channel or lowering the base grade. The steep-banked gullies in this land type are from 5 to 50 feet deep. Overfalls occur at the heads of the gullies.

Riverwash consists of sandbars within and adjacent to the channel of the Missouri River. These sandbars are from one to several feet above the normal flow of the stream. During floods, some sandbars disappear, and others are formed, or their size and shape are altered. The sandbars consist of a mixture of sand, silt, and clay that is darkened in places by organic material. Some sandbars are bare, and some are covered by weeds and small willows. Wind erosion is active on some of the unvegetated bars.

Diverting water and establishing grass and trees will help stabilize areas of Gullied land, Judson materials. Dams with drop inlet structures have been effective in reducing the grade of the water courses and stopping the advance of the overfalls.

Little can be done to stabilize Riverwash. As floods are decreased by large dams on the Missouri River, the areas in this land type will stay in place longer. Weeds, grass, and willows help stabilize this land type.

The land types in this unit provide an excellent habitat for wildlife. Proper management is needed to make these areas suitable for game and fish.

Yield Predictions

In table 2 the average acre yields of principal crops are predicted for two levels of management. The yields in columns A are those to be expected under ordinary management. This includes a crop rotation that provides some protection from erosion, control of insects and diseases, and maintenance of fertility. Under this system of management, seedbed preparation, plantings and tillage practices provide for adequate stands of adapted crops and for weed control.

The yields in columns B are those to be expected under a management system that controls erosion; maintains organic matter and soil tilth; provides for the level of fertility needed for each crop (as indicated by soil tests and field trials); controls the water level in wet soils; and provides for timely operations.

Predicted yields in table 2 are based on the data from tests made in the county and on the opinions of farmers, the county agricultural agent, representatives of the Soil Conservation Service, and supervisors of the Papio Soil and Water Conservation District. Yields will be higher in periods of above-average rainfall and will improve as new techniques and varieties are made available.

General Management of Cropland

Cultivated soils in Washington County require management that conserves moisture, controls erosion, and maintains fertility, organic matter, and good soil tilth. Most good farming practices accomplish more than one purpose and can be used on most of the cropland in the county.

Some of the crops and cropping practices used on the soils of Washington County are discussed next. The practices referred to in this section are discussed in "Capability Groups of Soils."

Crops and cropping practices [1]

Corn is by far the most extensively cultivated crop in Washington County. Other important crops are oats, winter wheat, grain sorghum, soybeans, and alfalfa. Some smaller acreages of barley, rye, forage sorghum, red clover, and sweet clover are also grown.

Corn is usually grown on the better soils in the county, but it is also grown on some of the steeper and severely eroded soils. It is planted in the first part of May on a seedbed generally prepared by plowing, disking, and harrowing. Methods used are listing in furrows and surface planting. A considerable acreage of the corn grown on the sloping fields is planted on the contour. Contours follow terrace lines. Corn is harvested in fall, usually in October and November, and the stalks are allowed to stand until seedbed preparation in spring. Some farmers graze livestock on the cornstalks during part of the winter.

Various methods that include minimum tillage in corn production are increasing in use. The most prevalent is the till-plant system. Operations in this system of corn tillage consist of (1) cutting or chopping stalks; (2) planting corn, using preemergence herbicides and insecticides; and (3) using a minimum number of cultivations, usually not more than two. The advantages of these sys-

[1] By E. O. PETERSON, conservation agronomist, Soil Conservation Service.

TABLE 2.—*Predicted average acre yields of principal crops*

Yields in columns A are those predicted under ordinary management; yields in columns B are those predicted under improved management; absence of yield indicates crop is not suited to the soil or is seldom grown on the soil]

Map symbol	Soil	Corn		Wheat		Oats		Soybeans		Alfalfa		Tame pasture (brome and alfalfa)	
		A	B	A	B	A	B	A	B	A	B	A	B
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Acres per animal unit* [1]	*Acres per animal unit* [1]
Au	Albaton clay	45	65	25	35	25	35	15	20	3	5	2. 0	1. 0
Ab	Albaton silt loam	45	65	25	35	25	35	20	25	3	5	1. 5	. 75
Bs	Belfore silty clay loam	45	60	25	30	35	45	20	25	2	4	2. 5	1. 0
BdC2	Burchard clay loam, 7 to 12 percent slopes, eroded	30	50	15	25	25	35	------	------	1. 5	3	4. 0	2. 0
BdD2	Burchard clay loam, 12 to 18 percent slopes, eroded	25	45	10	20	20	30	------	------	1. 5	3	6. 0	3. 0
Cg	Carr fine sandy loam	40	60	25	35	20	30	15	20	3	5	2. 0	1. 0
Cs	Cass fine sandy loam	40	60	20	30	20	30	15	20	3	5	3. 0	2. 0
Cm	Cass loam	45	65	25	35	25	35	20	25	3	5	3. 0	1. 5
CfC3	Crofton silt loam, 7 to 12 percent slopes, eroded	20	40	10	20	15	30	------	------	1. 5	2	7. 0	4. 0
CfD3	Crofton silt loam, 12 to 18 percent slopes, eroded	25	30	10	15	------	------	------	------	------	------	8. 0	5. 0
CfE	Crofton silt loam, 18 to 30 percent slopes	------	------	------	------	------	------	------	------	------	------	8. 0	5. 0
CfE3	Crofton silt loam, 18 to 30 percent slopes, eroded	------	------	------	------	------	------	------	------	------	------	10. 0	6. 0
GL	Gullied land, Judson materials	------	------	------	------	------	------	------	------	------	------	------	------
He	Haynie silt loam	45	65	25	35	25	35	20	25	3	5	1. 5	. 75
JuA	Judson silt loam, 1 to 3 percent slopes	60	70	30	35	45	55	20	30	3	4	1. 5	. 75
JuB	Judson silt loam, 3 to 7 percent slopes	45	65	25	35	35	50	20	25	2	3	2. 5	1. 0
Ke	Kennebec silt loam	60	70	30	35	45	55	20	30	3	4	1. 5	. 75
LC	Lamoure-Colo silty clay loams	40	60	20	30	30	45	20	25	------	------	2. 0	1. 0
Le	Leshara silt loam	55	65	25	35	25	35	20	25	3	5	3. 0	1. 5
2Le	Leshara soils, clayey substrata	60	70	30	35	45	50	20	30	3	4	1. 5	. 75
Lu	Luton clay	45	65	25	35	25	35	15	20	3	5	2. 0	1. 0
LLu	Luton and Leshara clays	45	65	25	35	25	35	15	20	3	5	2. 0	1. 0
Ls	Luton silty clay loam	45	65	25	35	25	35	20	25	3	5	2. 0	1. 0
Lt	Luton silt loam, overwash	45	65	25	35	25	35	20	25	3	5	1. 5	. 75
Mc	McPaul silt loam	60	70	30	35	45	55	20	30	3	4	1. 5	. 75
Mn	Monona silt loam, 0 to 1 percent slopes	60	70	30	35	45	55	20	30	2	4	1. 5	1. 0
MnA	Monona silt loam, 1 to 3 percent slopes	45	65	25	35	35	50	15	20	2	3	2. 5	1. 0
MnB	Monona silt loam, 3 to 7 percent slopes	50	70	25	35	35	50	20	25	3	4	2. 5	1. 0
MnB2	Monona silt loam, 3 to 7 percent slopes, eroded	45	65	25	35	35	50	15	20	2	3	2. 5	1. 0
MnC	Monona silt loam, 7 to 12 percent slopes	40	60	20	30	30	40	------	------	2	3	2. 5	1. 0
MnC2	Monona silt loam, 7 to 12 percent slopes, eroded	40	60	20	30	30	40	------	------	2	3	2. 5	1. 0
MCD	Monona-Crofton silt loams, 12 to 18 percent slopes	40	55	20	25	30	40	------	------	1. 5	2	3. 0	1. 5
MCD3	Monona-Crofton silt loams, 12 to 18 percent slopes, eroded	30	45	15	20	20	30	------	------	1. 5	2	6. 0	3. 0
MMB	Moody and Marshall soils; 3 to 7 percent slopes	45	65	25	35	35	50	20	25	3	4	2. 5	1. 0
MMB2	Moody and Marshall soils, 3 to 7 percent slopes, eroded	45	65	25	35	35	50	20	25	3	4	2. 5	1. 0
MMC	Moody and Marshall soils, 7 to 12 percent slopes	45	60	20	30	35	45	------	------	3	4	2. 5	1. 0
MMC2	Moody and Marshall soils, 7 to 12 percent slopes, eroded	45	60	20	30	35	45	------	------	3	4	2. 5	1. 0
NCC3	Nora and Crofton soils, 7 to 12 percent slopes, severely eroded	40	60	20	30	30	45	------	------	2	3	4. 0	2. 0
NCD3	Nora and Crofton soils, 12 to 18 percent slopes, severely eroded	30	45	15	20	20	30	------	------	1. 5	2	6. 0	3. 0
NC3	Nora and Marshall soils, 7 to 12 percent slopes, severely eroded	40	60	20	30	30	25	------	------	2	3	4. 0	2. 0
ND2	Nora and Marshall soils, 12 to 18 percent slopes, eroded	40	55	15	25	30	40	------	------	2	3	3. 0	1. 5

See footnote at end of table.

TABLE 2.—*Predicted average acre yields of principal crops*—Continued

Map symbol	Soil	Corn		Wheat		Oats		Soybeans		Alfalfa		Tame pasture (brome and alfalfa)	
		A	B	A	B	A	B	A	B	A	B	A	B
		Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Acres per animal unit* [1]	*Acres per animal unit* [1]
ND3	Nora and Marshall soils, 12 to 18 percent slopes, severely eroded	35	50	15	25	25	35	------	------	2	3	6. 0	3. 0
NMD2	Nora and Moody soils, 12 to 18 percent slopes, eroded	------	------	------	------	------	------	------	------	------	------	------	------
Ou	Onawa clay	45	65	25	35	25	35	15	20	3	5	2. 0	1. 0
OH	Onawa and Haynie silty clay loams	45	65	25	35	25	35	20	25	3	5	1. 5	. 75
Ra	Rauville soils	------	------	------	------	------	------	------	------	------	------	------	------
Rw	Riverwash	------	------	------	------	------	------	------	------	------	------	------	------
Sv	Salix and Volin silt loams	45	65	25	35	25	35	20	25	3	5	1. 5	. 75
Sg	Sarpy loamy fine sand	15	35	------	------	10	20	------	------	------	------	3. 0	2. 0
Sl	Sarpy loam	20	40	10	20	10	20	10	20	------	------	3. 0	2. 0
Sh	Sharpsburg silty clay loam, 0 to 1 percent slopes	45	60	25	30	35	45	20	25	2	4	2. 5	1. 0
SMA	Sharpsburg and Marshall soils, 1 to 3 percent slopes	45	65	25	35	35	50	20	25	2	4	2. 5	1. 0
SMB	Sharpsburg and Marshall soils, 3 to 7 percent slopes	45	65	25	35	35	50	20	25	3	4	2. 5	1. 0
SMB2	Sharpsburg and Marshall soils, 3 to 7 percent slopes, eroded	45	65	25	35	35	50	20	25	3	4	2. 5	1. 0
SMC	Sharpsburg and Marshall soils, 7 to 12 percent slopes	45	60	20	30	35	45	------	------	3	4	2. 5	1. 0
SMC2	Sharpsburg and Marshall soils, 7 to 12 percent slopes, eroded	45	60	20	30	35	45	------	------	3	4	2. 5	1. 0
S	Spoil banks	------	------	------	------	------	------	------	------	------	------	------	------
StD2	Steinauer soils, 12 to 18 percent slopes, eroded	------	------	------	------	------	------	------	------	------	------	8. 0	5. 0

[1] Number of acres required to support one cow for 6 months.

tems are reduced cost of operations and less soil erosion because of the surface mulch of stalks.

Other row crops grown are soybeans and both grain and forage varieties of sorghum. Soybeans are grown on the more nearly level fields of the county. Grain sorghum is used as a substitute for corn. Planting dates for these row crops are about the same as for corn. Soybeans are usually harvested before corn, about the time of the first-killing frost in fall. Grain sorghum is also usually harvested just before corn.

Oats are the most prevalent small grain planted in spring. The acreage in this crop is about one-fourth of that in corn. Oats are planted on disked ground early in spring, as soon as the soil can be worked. Most of the crop is seeded by the broadcast method. This crop is harvested for grain early in July and is also used as a nurse crop for legume seedings.

Very small acreages of barley and rye are grown for grain or pasture. Barley is planted in spring, and rye in fall.

Winter wheat is planted in fall on plowed stubble land and is harvested in the early part of July. At present, less than one-twentieth of the acreage in the county is used for winter wheat. The grain is usually combined, and the straw is returned to the soil as a mulch material.

Alfalfa is grown for hay or silage for livestock. Some alfalfa grown near alfalfa mills is dehydrated and made into meal or pellets. Stands of alfalfa are allowed to remain for several years, or as long as they remain productive and free of weeds. On some of the acreage, alfalfa is planted with bromegrass. The addition of a grass to the alfalfa planting helps control erosion on sloping land. The alfalfa plant grows in a bunch; the spaces between the plants are not protected from erosion unless there is a sod-forming grass in the field. During a series of years with below-normal rainfall, the deep-rooted alfalfa plant can exhaust the supply of moisture in the subsoil.

Sweet clover and red clover are grown as green-manure crops in a cropping system. These crops are planted with oats and stay on the land until the following spring, when they are plowed under as green manure. Some small acreages of these crops are harvested for seed.

Less than 1 percent of the acreage in crops in the county is irrigated. The irrigated area is confined to the river bottom lands. Here aquifers that yield sufficient water are available. Water is obtained from wells and is applied to the land by gravity systems. Corn is the main crop grown on irrigated areas.

At one time fruit orchards were grown on small acreages near Blair. The Crofton soils with slopes of 12 percent or more on these areas are well adapted to orchards and vineyards. Good air drainage on the long slopes reduces damage by spring frost. Soil and moisture conservation practices will help maintain production.

GENERAL PRACTICES OF MANAGEMENT

The climate in Washington County is favorable for crop production. The average rainfall is 26 inches; the major part occurs late in spring and in summer. Generally there is enough moisture to produce good yields of corn—the major crop.

The most productive bottom lands are used for corn. Some areas of low-lying land that are flooded by runoff from the uplands are used for pasture. These areas could be used for crops if water conservation and erosion control practices were used on the uplands, and diversion terraces and drainage operations were used on the bottom lands. Farmers could then use the steeper and eroded upland areas for pasture, which would provide protection against runoff and erosion.

The cropping system used on upland areas includes several years of corn followed by 1 year of small grain seeded with a legume. The legume may be either alfalfa, which remains on the field for several years, or a clover, such as sweet clover or red clover. The clover is used as a green-manure crop and is plowed under during the seedbed preparation for a corn crop.

Because of insect problems when the stand is being established, and deficiencies in soil moisture, the acreage in sweet clover has declined. The green manure from the crop of spring-plowed sweet clover or red clover is beneficial to corn. The organisms have completed the breakdown of organic matter about the time the corn needs a good supply of nitrate.

Wheat is grown by some farmers on soil that was previously in small grain or hay. On such areas one hay crop can be cut, the land plowed, and a seedbed prepared for fall seeding of the wheat.

Fields in steep, eroded areas are used mostly for small grain, hay, and pasture. Corn is grown in the cropping system only part of the time; the time varies according to the erosion hazard. The flat bottom-land fields that have well-drained soils are used almost continuously for corn.

Commercial nitrogen fertilizer is used for corn and small grain and for bromegrass pastures. Phosphate is used mainly for alfalfa, corn, and small grain. The use of commercial fertilizer has been increasing in Washington County.

Terraces are built to save moisture and to control soil erosion. Terraced areas are tilled on the contour; the terraces are followed as guidelines. Grassed waterways are located in natural drainageways. They carry off excess water from the terraces without causing erosion. Diversion terraces are constructed at the junction of long slopes and bottom lands. They are built to dispose of runoff in areas where erosion is not a problem, and also to prevent flooding of the lower lying bottom lands.

Use of Soils for Pasture [2]

Most pastures in Washington County consist of bromegrass. A part of the acreage of bromegrass is mixed with legumes, primarily alfalfa.

Some areas are still in native vegetation. These areas are mostly on the very steep Crofton soils of the Missouri River bluffs and on the Leshara and Lamoure-Colo soils in the low, wet valleys. The acreage in native vegetation is not extensive.

Management

Best results are obtained by limiting grazing during the critical period of growth early in spring. Until the grasses reach a height of 5 or 6 inches, they are growing on food reserves stored in their roots and rhizomes. They should also be allowed to grow 6 or 8 inches high before killing frosts occur in fall, as they thus store food reserves for growth the next spring.

Weeds can best be controlled in pastures by the use of chemicals. Mowing of weeds is not desirable. The taller grasses are clipped with the weeds and may be damaged as much as the weeds.

Adequate fertilizer is necessary for the best production of grass. Nitrogen fertilizer is most likely to be needed. If a legume has been included in the pasture mixture, phosphate fertilizer is generally essential. Adequate soil tests and the amount of available soil moisture should be used as guides in determining the amount and kinds of fertilizer to be applied.

Overgrazing of bromegrass pastures should be avoided. During the months of July and August, bromegrass and most other cool-season pasture grasses are in a semidormant stage and are growing slowly. Temporary pastures of sudangrass can be used for grazing during these months.

Under the heading "Tame pasture" in table 2 (Predicted average acre yields of the principal crops), the stocking capacity of the various soils of the county is shown. These data can be used as a guide that will help in determining the number of cattle that can be feasibly pastured.

Green grazing for livestock can be provided throughout the growing season by using a combination of several pastures. This combination includes a cool-season grass pasture, such as bromegrass and alfalfa; a predominately warm-season grass pasture, such as switchgrass, bluestem, or Indiangrass; and a temporary sudangrass pasture.

Grass seedings

There are two types of grass seedings suitable for this county: (1) A seeding of cool-season grasses, and (2) a seeding of native range grasses. Most of the native grasses grow during the warmer season of the year; these grasses were originally on the land. Generally, the cool-season grasses are the introduced, or exotic, species.

The greatest net returns from pastures on soils in capability classes I, II, and III may be obtained from cool-season grasses that are adequately fertilized. Soils in capability classes V and VI give good returns when planted to a mixture of predominantly native, warm-season grasses. On soils in capability class IV, either cool-season or warm-season grasses can be used.

Seedbeds designed to reduce competition from weeds and weedy grasses are especially necessary for plantings of warm-season native grasses. To help reduce weed competition, grow grain sorghum or thickly seeded sudangrass for cover. In some areas 2 years of such a cover crop may be needed. Drill the grass seed into the stubble. A stand of sorghum stubble, 12 to 18 inches tall, is the most desirable seedbed.

Grass seeds should be planted about ½ to ¾ inch deep. The soils should be firmed over the seed.

Cool-season grasses may be planted during early spring and late summer. The best time to plant warm-season grasses is during the corn-planting season. Good stands of both cool-season and warm-season grasses have resulted from seedings made during the winter when the ground is not frozen.

[2] By E. O. PETERSON, conservation agronomist, Soil Conservation Service.

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If stands of broadleaf weeds develop thickly enough to shade the ground completely, they should be sprayed or mowed when 4 to 6 inches tall. Spraying is preferred. If weedy grasses develop a thick stand, they should be mowed early. The best time to mow grass is when more of the weeds can be cut off than of the seeded grasses.

Use of Soils for Woodland[8]

Washington County lies in the hilly part of the State that borders the Missouri River. The natural forest growth is mainly on the bluffs and bottom lands along the Missouri and Elkhorn Rivers. Some fringe growth, primarily willow and cottonwood, occurs along some of the smaller streams. There is also a limited growth of boxelder, elm, ash, and hackberry.

On the upper slopes and crests of hills along the bluffs of the Missouri and Elkhorn Rivers, the main growth was scrubby bur oak and sumac. On the lower slopes and in draws, the forests consisted of American and red elm, green ash, boxelder, bitternut hickory, basswood, hackberry, and black walnut.

Much of this forested area has been cleared and is farmed. Wooded bottom lands are now being cleared rapidly.

Most of the merchantable timber, consisting mainly of black walnut, has been harvested from the stands. The remaining woodland produces little more than fuel wood, fencepost material, and limited grazing.

Small, isolated areas on the lower slopes and in draws that cannot be farmed and that provide very little pasture should be managed for production of valuable black walnut timber.

Tree planting

Trees are planted in the county for wind barriers and wildlife habitats and for improving present woodlands. Successful establishment of trees is not difficult, but certain techniques should be used.

Site preparation

Proper site preparation is necessary for successful tree planting. The preparation varies for different sites. On all grass or alfalfa sites, summer fallow is needed to store moisture and to kill all grass vegetation. On stubble ground, fall or spring plowing and spring disking are generally adequate.

Site preparation is needed for underplanting in woodland areas that have a heavy ground cover. An 18-inch spot should be scalped for each seedling at the time of planting.

Farmstead and feedlot protection

Windbreaks for protecting farmsteads and feedlots in winter should be wide enough to hold most of the snow (fig. 24). From 7 to 10 rows of trees are needed. The trees should be located on the north and west sides of the area to be protected and not closer than 100 feet from the main buildings.

To provide a satisfactory barrier, these windbreaks should include a combination of low shrubby growth, medium-height trees, and tall-growing trees. They should be at least 50 percent evergreen species, for adequate winter protection and longer life. Redcedar has a dense growth to the ground and makes an excellent outside row.

Figure 24.—**A good windbreak gives winter protection for the farm family and their livestock.**

The many benefits derived from a well-planned and carefully maintained windbreak will more than repay the planter for the expense and labor involved. Windbreaks control snow drifting in yards, control soil blowing, reduce cost of winter fuel, provide livestock shelter that will help reduce feed cost, protect gardens, and beautify the farm home.

Field windbreaks or shelterbelts

In Washington County field windbreaks can be used only to a limited extent because of the rough topography. Those in the more nearly level, cultivated areas help control soil blowing, increase soil moisture by holding snow on the fields, control damage to growing crops by strong winds, reduce evaporation, and furnish food and cover for wildlife. These benefits can be obtained if fields are protected by a complete series of windbreaks at regular intervals. Tree belts offer protection for a distance equal to about 20 times the height of the barrier. Wide belts are not needed for protecting fields, and the narrow belts should consist of dense-growing species that will not sap the moisture from the field. One- to five-row belts, chiefly of redcedar and pine, are needed.

Planting sites and suitable species

In table 3 the soils of Washington County are placed in four woodland sites, according to their capacity to support similar tree growth.

Maintenance of tree plantings

The highest survival rate and reasonably fast growth are obtained if young trees are clean cultivated until they have enough growth to shade out competing weeds. Usually they have this much growth in 5 to 6 years.

Complete and permanent protection from livestock is necessary if a satisfactory wind barrier is to be maintained.

Technical assistance and advice about site preparation, choice of species, spacing of trees, planting methods, and maintenance may be obtained from the county agricul-

[8] By SIDNEY S. BURTON, woodland conservationist, Soil Conservation Service.

TABLE 3.—*Woodland sites and species suitable for planting*

Woodland site and series	Capability units	Species suitable for planting
Silty to clayey: *All deep, well-drained, silty, clayey, or claypan soils except the saline-alkali soils.*		
Belfore	IIe-1	*Shrubs:* Lilac, cotoneaster, Tatarian honeysuckle, and chokecherry. *Conifers:* Redcedar, Rocky Mountain juniper, Austrian pine, ponderosa pine, Scotch pine, and Colorado blue spruce. *Broadleaf trees:* Mulberry, Russian-olive, green ash, hackberry, honeylocust, bur oak, black walnut, wild black cherry, American elm, and Siberian elm.
Burchard	IIIe-1, IVe-1	
Cass (loam)	I-1	
Crofton	IIIe-8, IVe-8, VIe-1, VIe-8	
Judson	I-1, IIe-1	
Kennebec	I-1	
Monona	I-1, IIe-1, IIIe-1	
Monona-Crofton.	IVe-1, IVe-8	
Moody and Marshall.	IIe-1, IIIe-1	
Nora and Crofton.	IIIe-8, IVe-8	
Nora and Marshall.	IIIe-8, IVe-1, IVe-8	
Nora and Moody.	IVe-1	
Salix and Volin	I-1	
Sharpsburg	I-1	
Sharpsburg and Marshall.	IIe-1, IIIe-1	
Steinauer	VIe-1	
Sandy: *Slightly sandy and nearly level very sandy soils.*		
Cass (fine sandy loam).	IIe-3	*Shrubs:* Tatarian honeysuckle, three-leaved sumac, Nemaha plum, and American plum. *Conifers:* Redcedar, ponderosa pine, Scotch pine, and Austrian pine. *Broadleaf trees:* Mulberry, boxelder, green ash, honeylocust, Siberian elm, and cottonwood.
Moderately wet: *Soils in depressions on bottom lands, benches, and uplands that are occasionally wet because of high water table or flooding; some areas are flooded frequently for a short time.*		
Albaton	IIIw-1, IIIw-2	*Shrubs:* Red-osier dogwood, purple willow, buffaloberry, and chokeberry. *Conifers:* Redcedar and Scotch pine. *Broadleaf trees:* Russian-olive, diamond willow, mulberry, boxelder, green ash, honeylocust, black walnut, golden willow, white willow, and cottonwood.
Carr	IIIw-6	
Haynie	IIw-4	
Lamoure-Colo	IIw-4	
Leshara	IIw-3, IIw-4	
Luton	IIw-4, IIIw-1	
Luton and Leshara.	IIIw-1	
McPaul	IIw-3	
Onawa	IIIw-1	
Onawa and Haynie.	IIw-4	
Sarpy	IIw-4, IIIw-5	
Wet: *Soils in depressions on all bottom lands, benches, and uplands that are extremely wet because of flooding, high water table, or poor drainage.*		
Rauville	Vw-1	*Shrubs:* Purple willow and red-osier dogwood. *Conifers:* None. *Broadleaf trees:* Diamond willow, golden willow, white willow, cottonwood, and silverleaf poplar.

tural agent, the Soil Conservation Service, or the State forester.

Wildlife and Its Management[4]

The kinds and amounts of wildlife that can be produced and maintained in this county are largely determined by the kinds and amounts of vegetation the soils can produce, and by the manner in which this vegetation is distributed.

Wildlife is influenced by topography and by such soil characteristics as fertility. Fertile soils are capable of greater wildlife production, and waters that drain from such soils generally will produce more fish than waters that drain from infertile soils. Topography affects wildlife through its influence on land use. Extremely rough, irregular areas may present hazards to livestock and be unsuited to crop production. In such areas the undisturbed vegetation is often valuable to wildlife. If suitable vegetation is lacking in such areas, it can often be developed to improve conditions for desirable kinds of wildlife.

Wetness and water-holding capacity of the soils are important in selecting sites for constructing ponds for fish and in developing and maintaining habitats for waterfowl. Swampy and marshy areas can be used for the development of aquatic and semiaquatic habitats of value to waterfowl and to some species of furbearers.

The soils of Washington County provide suitable habitats for a number of wildlife species. Important species of game in the area are quail, pheasant, deer, cottontail rabbit, and squirrel. Opossum, raccoon, weasel, mink, badger, fox, and skunk are found in various areas throughout the county. Beaver are found around farm ponds and on streams and waterways.

Factors of the kind mentioned in the foregoing paragraphs were considered in preparing table 4, which shows the potential of the soil associations in the county for pro-

[4] By CHARLES V. BOHART, biologist, Soil Conservation Service.

ducing habitats for the more important species of game in Washington County. The last column in the table, titled "Food," shows by means of ratings, the capacity of the soil association to provide the kinds of food plants needed by the kind of wildlife specified. The ratings of *very good*, *good*, and *fair* take into account the soils and the characteristics of the soils that affect their potential for producing the kinds of vegetation needed for wildlife habitat.

A variety of birds inhabit the county throughout the year. Migrations of waterfowl in spring and fall are a familiar site along the Missouri River, which forms the eastern boundary of the county. Mallard, teal, and some wood duck nest and reproduce in suitable areas. The DeSoto Bend National Wildlife Refuge near Blair provides feeding and resting areas for migratory waterfowl that follow the Missouri River flyway. This area also provides facilities for fishing and other recreation.

The Missouri River contains the most important fishing resource in Washington County. Fish are also in the Elkhorn River, in other permanent creeks, and in farm ponds that have been stocked with bass, bluegill, and channel catfish. Commercial fishing is carried on in the Missouri River. Its waters contain channel and flathead catfish, paddlefish, crappie, sauger, drum, carp, and buffalofish.

The wildlife resources of Washington County are important primarily for the opportunities for recreation they provide. Many species of wildlife, however, are also beneficial in the control of undesirable insects and rodents.

The combination of soils, topography, and vegetation in Washington County provides an opportunity for developing facilities for outdoor recreation. It is likely that fish and wildlife resources would be developed. Nevertheless, increased travel by the American public also provides other opportunities for using suitable soils for recreational purposes. Use of soils for overnight camping facilities or for picnic areas along main highways can provide a real convenience to travelers and an additional source of income to landowners.

TABLE 4.—*Potential of soil associations for producing habitats for the more important wildlife* [1]

Soil association	Wildlife	Potential for producing, for species of wildlife—			
		Woody cover	Herbaceous cover	Aquatic environment	Food
Cass-Leshara	Deer	Very good	Good		Good.
	Quail	Good	Fair		Fair.
	Cottontail rabbit	Very good	Very good		Very good.
	Squirrel	Very good			Very good.
	Waterfowl			Good	Good.
	Furbearers	Good	Good	Good	Good.
	Fish			Good	
Moody-Belfore	Deer	Fair	Fair		Good.
	Quail	Fair	Fair		Good.
	Pheasant	Very good	Very good		Very good.
	Cottontail rabbit	Good	Good		Good.
	Furbearers	Fair	Fair	Fair	Fair.
Sharpsburg-Marshall	Quail	Good	Good		Very good.
	Pheasant	Good	Good		Very good.
	Cottontail rabbit	Good	Good		Good.
	Furbearers	Fair	Fair		Fair.
	Fish			Good	
Monona-Crofton	Deer	Very good	Good		Good.
	Quail	Good	Good		Good.
	Pheasant	Fair	Fair		Fair.
	Cottontail rabbit	Good	Good		Good.
	Squirrel	Good			Good.
	Furbearers	Fair	Fair	Fair	Fair.
	Fish			Good	
Luton-Volin	Deer	Fair	Fair		Good.
	Quail	Very good	Very good		Very good.
	Pheasant	Good	Good		Very good.
	Cottontail rabbit	Good	Good		Good.
Albaton-Haynie	Deer	Good	Good		Good.
	Quail	Good	Good		Very good.
	Pheasant	Fair	Fair		Very good.
	Cottontail rabbit	Good	Good		Good.
	Squirrel	Fair			Good.
	Waterfowl			Very good	Very good.

[1] Development of specific habitat for wildlife requires proper location and distribution of the kind of vegetation that the soils can produce. Technical assistance in planning wildlife developments and determining which species of the vegetation to use can be obtained at the District Office of the Soil Conservation Service. Additional information and assistance can be obtained from the Nebraska Game, Forestation, and Parks Commission, Bureau of Sports, Fisheries, and Wildlife, and from the Extension Service.

Wildlife is a product of soil and water. Each area has a certain capacity for wildlife production, depending on the habitat that is provided. Where grassland is converted to cropland, there is a loss of cover for some kinds of animals. In turn, an improved food supply is made available for others.

Areas where trees and shrubs are planted for field and farmstead windbreaks meet another need of some species of wildlife. Farm ponds often provide opportunities for improving habitats for wildlife. Herbaceous and woody plantings around ponds provide cover for wildlife, and proper stocking and management of the water can produce annual crops of fish.

Some areas of land are more suitable for wildlife production than for the production of crops. These areas can be improved for wildlife by protecting natural cover or by establishing needed cover.

Engineering Uses of Soils [5]

Some soil properties are of special interest to engineers because they affect measures for soil and water conservation and the construction and maintenance of roads, airports, pipelines, building foundations, earth dams for storage of water, erosion control structures, irrigation and drainage systems, and sewage disposal systems. Some of the soil properties important to engineers are texture, permeability, shrink-swell potential, plasticity, shear strength, moisture-density relationships, workability, and water-holding capacity. Information on site conditions, such as kind of topography, water table data, depth to bedrock or sand and gravel, are also important.

Information in this report can be used to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of engineering properties of soils in planning agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other soil and water conservation measures.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed investigations at selected locations.
4. Estimate drainage areas and runoff characteristics for use in designing culverts and bridges.
5. Classify soils along the proposed highway route for use in making preliminary estimates of required thickness of flexible pavements.
6. Estimate the need for clay to stabilize the surfacing on roads that are not paved.
7. Locate deposits of sand, gravel, rock, mineral filler, and soil binder for use in construction of subbase courses, base courses, and surface courses of flexible pavements for highways and other structures.
8. Make preliminary evaluations of terrain conditions, such as topography, surface drainage, subsurface drainage, and height of water table, in connection with the design of highway embankments, subgrades, and pavements.
9. Correlate performance of engineering practices and structures with types of soil and thus develop information that will be useful in designing and maintaining these engineering practices and structures.
10. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
11. Supplement information obtained from other published maps and reports and from aerial photographs for the purpose of making soil maps and reports that can be readily used by engineers.
12. Develop other preliminary estimates for construction purposes pertinent to the particular area.

This report will not eliminate the need for, or take the place of, on-site sampling and testing of soils for design and construction of specific engineering works. It may be useful in planning more detailed field investigations to determine the in-place condition of the soil at the site of the proposed construction.

Some of the terms used by the agricultural soil scientist may be unfamiliar to the engineer, and some words have special meanings in soil science. These terms are defined in the Glossary. Some of the terms used by engineers are defined in this section.

Engineering classification systems

Two systems of classifying soils, the AASHO and the Unified, are generally used by engineers and are used in this report. Persons using this report are assumed to be familiar with these classification systems or to have available reference material on them. Therefore, detailed information on these systems will not be included in this report.

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (*1*).[6] In this system soil materials are classified in seven principal groups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, which is made up of clay soils having low strength when wet. Within each group, the relative engineering value of the material is indicated by a group index number. The group index number for the soil groups A–1 and A–3 is 0. For the poorest soils in group A–2, the group index is 4; in groups A–4, 8; in group A–5, 12; in group A–6, 16; and in group A–7, 20. The group index number is shown in parentheses, following the soil group symbol, in the next to last column of table 5.

Many engineers prefer to use the Unified soil classification system (*14*). This system is based on identification of soils according to their texture and plasticity, and the soils are grouped according to their performances as engineering construction materials. The system establishes 15 soil classes which are put in 3 groups: Coarse-grained soils (8 classes), fine-grained soils (6 classes), and highly organic soils (1 class). These classes are designated by pairs of letters. The classes range from GW, which consists of well-graded gravel, gravel and sand mixtures, and a little fine material, to Pt, which consists of peat and other highly organic soils. The soils of this county have

[5] This section prepared by LEE E. SMEDLEY, assistant State conservation engineer, Soil Conservation Service, with the assistance of WILLIAM J. RAMSEY, senior geologist, Division of Materials and Tests, Nebraska Department of Roads. The work by the Department of Roads was done under a cooperative agreement with the U.S. Department of Commerce, Bureau of Public Roads.

[6] Italic numbers in parenthese refer to Literature Cited, p. 76.

TABLE 5.—*Engineering*

Soil name	Parent material	Nebraska Dept. of Roads or Bureau of Public Roads report No.	Depth	Horizon	Moisture-density [2] Maximum dry density	Moisture-density [2] Optimum moisture
			Feet		*Lbs. per cu. ft.*	*Percent*
Belfore silty clay loam: [7] 400 feet west and 100 feet south of NE. corner, NW¼ sec. 3, T. 18N., R. 9 E.	Peorian loess	S32538	0– 0.5	Alp	102	20
		S32539	1.7– 2.5	B22	103	20
		S32540	3.5– 5.0	C	104	20
Colo silty clay loam (applicable to Lamoure-Colo silty clay loams): 670 feet west and 495 feet south of NE. corner, sec. 13, T. 17 N., R. 10 E.	Alluvial silt and clay	S58314	0– 1.0	Upper layer	----------	----------
		S58317	1.0– 2.8	Middle layer	----------	----------
		S58315	2.8– 4.0	Lower layer	----------	----------
Crofton silt loam, 18 to 30 percent slopes, eroded: 430 feet north on Highway No. 133 from the south sec. line; sec. 23, T. 18 N., R. 11 E. (40 feet west of highway).	Peorian loess	No sample	0– 0.5	Upper layer	----------	----------
		S573337	0.5– 4.5	Middle layer	----------	----------
		S573338	4.5–20.0	Lower layer	----------	----------
Luton clay: [7] 175 feet west and 80 feet north of SE. corner, NE¼ sec. 28, T. 20 N., R. 11 E. (Some CaSo4).	Alluvial clay (flood plains).	S32514	0.5– 1.0	Alb	89	29
		S32515	2.0– 2.8	Al2b2	90	30
		S32516	4.1– 5.0	Ccab2	91	29
Luton clay: [7] 300 feet east and 100 feet south of NW. corner, sec. 10, T. 19 N., R. 11 E. (No gypsum).	Alluvial clay (flood plains).	S32517	0– 0.4	Alp	89	28
		S32518	1.3– 2.1	Alb2	88	29
		S32519	3.8– 5.0	Cgca	90	29
Marshall silty clay loam, 7 to 12 percent slopes: 1,710 feet west and 330 feet south of NE. corner, sec. 13, T. 17 N., R. 10 E.	Peorian loess	S58312	0– 0.8	Upper layer	95	24
		S58316	0.8– 2.5	Middle layer	----------	----------
		S58318	2.5–14.0	Lower layer	104	21
Marshall silty clay loam, eroded: [7] 0.3 mile west and 180 feet south of NE. corner, sec. 30, T. 18 N., R. 11 E. (Lime at 100 inches).	Peorian loess	S32526	0– 0.5	Alp	99	21
		S32527	1.5– 2.2	B22	101	22
		S32528	4.5– 5.4	C	107	19
Marshall silty clay loam, eroded: [7] 450 feet west and 110 feet north of SE. corner, SW¼ sec. 29, T. 17 N., R. 11 E.	Peorian loess	S32529	0– 0.6	Alp	101	20
		S32530	1.2– 2.1	B22	104	21
		S32531	4.0– 5.0	C	107	19
Monona silt loam: [7] 0.15 mile north and 100 feet west of SE. corner, sec. 18, T. 19 N., R. 11 E.	Peorian loess	S32532	0– 0.5	Alp	100	21
		S32533	1.2– 2.2	B22	104	20
		S32534	4.0– 5.1	C	105	20
Monona silt loam: [7] 0.2 mile west and 1,200 feet south of NE. corner, NW¼ sec. 18, T. 17 N., R. 12 E.	Peorian loess	S32535	0– 0.5	Alp	104	19
		S32536	1.9– 2.9	B22	105	20
		S32537	4.0– 5.0	C	106	19
Monona silt loam, 0 to 1 percent slopes: 520 feet north of Highway No. 133 from the south sec. line of sec. 2, T. 17 N., R. 11 E. (40 feet west of highway).	Peorian loess	S573343	0– 1.0	Upper layer	----------	----------
		S573344	1.0– 4.5	Middle layer	----------	----------
		S573345	4.5–10.0	Lower layer	----------	----------
Moody silty clay loam, eroded: [7] 0.1 mile east of SW. corner, SE¼ sec. 5, T. 19 N., R. 9 E.	Peorian loess	S32544	0– 0.5	Alp	98	23
		S32545	0.8– 1.9	B21	100	22
		S32546	3.5– 5.0	C	106	20

See footnotes at end of table.

test data [1]

Mechanical analysis [3]									Liquid Limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—						AASHO [5]	Unified [6]
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 50[4] (0.297 mm.)	No. 60[4] (0.250 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
--------	--------	--------	100	99	95	65	38	33	38	13	A-6(9)	ML-CL.
--------	--------	--------	100	99	95	63	37	32	50	26	A-7-6(16)	CL.
--------	--------	--------	--------	100	95	65	38	33	46	23	A-7-6(14)	CL.
--------	100	99	--------	98	94	--------	38	--------	52	23	A-7-6(16)	MH-CH.
--------	--------	100	--------	99	93	--------	39	--------	50	22	A-7-6(15)	ML-CL.
--------	--------	100	--------	99	90	--------	35	--------	49	21	A-7-6(14)	ML-CL.
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
--------	--------	--------	--------	100	91	--------	25	--------	36	12	A-6(9)	ML-CL.
--------	--------	--------	--------	100	95	--------	26	--------	35	10	A-4(8)	ML-CL.
--------	--------	--------	--------	100	98	90	75	64	87	53	A-7-5(20)	CH.
100	99	--------	98	96	([8])	--------	--------	--------	90	58	A-7-5(20)	CH.
--------	100	--------	99	98	([8])	--------	--------	--------	100	63	A-7-5(20)	CH.
--------	--------	--------	--------	100	99	91	77	65	78	44	A-7-5(20)	MH-CH.
--------	--------	--------	--------	100	98	92	84	71	92	55	A-7-5(20)	CH.
100	99	--------	99	98	97	92	80	66	93	53	A-7-5(20)	MH-CH.
--------	--------	100	--------	99	90	--------	35	--------	42	14	A-7-6(10)	ML.
100	99	99	--------	98	92	--------	42	--------	59	30	A-7-6(20)	MH-CH.
--------	--------	100	--------	98	87	--------	32	--------	48	23	A-7-6(15)	CL.
--------	--------	--------	--------	100	97	68	40	34	44	18	A-7-6(12)	ML-CL.
--------	--------	--------	--------	100	97	68	39	34	52	25	A-7-6(16)	MH-CH.
--------	--------	--------	--------	100	95	65	35	28	43	19	A-7-6(12)	CL.
--------	--------	--------	--------	100	97	68	38	33	44	17	A-7-6(12)	ML-CL.
--------	--------	--------	--------	100	97	64	36	32	49	23	A-7-6(15)	ML-CL.
--------	--------	--------	--------	100	97	65	35	30	42	18	A-7-6(12)	ML-CL.
--------	--------	--------	--------	100	97	68	36	30	41	16	A-7-6(11)	ML-CL.
--------	--------	--------	--------	100	97	71	37	30	49	24	A-7-6(15)	CL.
--------	--------	--------	--------	100	97	65	33	27	45	21	A-7-6(13)	CL.
--------	--------	--------	--------	100	97	66	32	27	36	11	A-6(8)	ML-CL.
--------	--------	--------	--------	100	97	68	32	28	44	19	A-7-6(12)	ML-CL.
--------	--------	--------	--------	100	97	65	32	26	40	17	A-6(11)	CL.
100	99	98	--------	97	89	--------	29	--------	41	13	A-7-6(9)	ML.
--------	--------	100	--------	99	94	--------	34	--------	43	15	A-7-6(11)	ML-CL.
--------	--------	100	--------	99	91	--------	30	--------	41	16	A-7-6(11)	ML-CL.
--------	--------	--------	--------	100	97	66	43	37	44	17	A-7-6(12)	ML-CL.
--------	--------	--------	--------	100	97	67	41	35	53	26	A-7-6(17)	MH-CH.
--------	--------	--------	--------	100	97	65	38	33	44	21	A-7-6(13)	CL.

TABLE 5.—*Engineering*

Soil name	Parent material	Nebraska Dept. of Roads or Bureau of Public Roads report No.	Depth	Horizon	Moisture-density [2]	
					Maximum dry density	Optimum moisture
			Feet		*Lbs. per cu. ft.*	*Percent*
Moody silty clay loam, eroded: [7] 0.2 mile east and 85 feet south of NW. corner, sec. 15, T. 18 N., R. 9 E.	Peorian loess	S32547	0– 0. 4	A1p	98	23
		S32548	1. 0– 2. 0	B22	101	21
		S32549	3. 8– 5. 0	C2	107	20
Sharpsburg silty clay: [7] 350 feet north and 100 feet west of SE. corner, SW¼ sec. 28, T. 19 N., R. 10 E.	Peorian loess	S32520	0. 4– 1. 0	A12	97	22
		S32521	2. 0– 3. 0	B22	99	22
		S32522	4. 0– 5. 0	C	104	20
Sharpsburg silty clay: [7] 800 feet west and 75 feet north of center of sec. 3, T. 17 N., R. 10 E. (Calcareous at 65 to 84 inches).	Peorian loess	S32523	0. 5– 1. 0	A12	98	23
		S32524	2. 0– 3. 0	B22	99	22
		S32525	3. 8– 5. 0	C	105	21
Sharpsburg silty clay loam, 0 to 1 percent slopes: [7] 180 feet south and 135 feet west of NE. corner, SE¼NE¼ sec. 25, T. 17 N., R. 10 E.	Peorian loess	S32541	0– 0. 6	A1p	103	20
		S32542	1. 5– 2. 5	B22	102	22
		S32543	4. 0– 5. 0	C	106	19
Sharpsburg silty clay loam, 0 to 1 percent slopes: 365 feet east and 260 feet south of NW. corner, sec. 4, T. 17 N., R. 10 E.	Peorian loess	S594346	0– 1. 0	Upper layer	96	21
		S594350	1. 0– 2. 6	Middle layer	102	19
		S594354	2. 6– 9. 0	Lower layer	104	19
Sharpsburg silty clay loam, 0 to 1 percent slopes: 4,090 feet north and 35 feet east of SW. corner, sec. 4, T. 17 N., R. 10 E.	Peorian loess	S594345	0– 1. 0	Upper layer		
		S594349	1. 0– 2. 5	Middle layer		
		S594353	2. 5– 9. 0	Lower layer		

[1] Tests performed by the Division of Materials and Tests, Nebraska Department of Roads and Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Based on the "Moisture-Density Relations of Soils, Using 5.5-lb. Rammer and 12-in. Drop," AASHO Designation: T 99–57 (*1*). Method A was used by Bureau of Public Roads and method C by Nebraska Department of Roads.

[3] Mechanical analysis according to the American Association of State Highway Officials Designation T 88. Results of this procedure frequently differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming tex-

been classified only in the SP, SM, SC, SW, ML, CL, CH, and MH classes of material.

Boundary classifications are provided for soils that have characteristics of two classes. The system provides for a simple field method and a laboratory method for determining the amount and type of basic constituents of the soils. Both methods are based on gradation and plasticity and vary only in degree of accuracy. The laboratory method uses mechanical analyses, liquid limit data, and plasticity index for an exact classification. A plasticity chart, on which the liquid limit and the plasticity index may be plotted, is used for a more accurate classification of the fine-grained soils. The classification of the tested soils, according to the Unified system, is given in the last column of table 5.

Engineering test data

To be able to make the best use of the soil maps and the soil survey reports, the engineer should know the physical properties of the soil materials and the condition of the soil in place. After testing soil materials and observing the behavior of soil in engineering structures and foundations, the engineer can develop design recommendations for the soil units that are mapped.

Table 5 shows engineering test data for samples of 9 different soil types taken at 18 sampling sites. These samples were taken and tested according to the standard procedures of the American Association of State Highway Officials (AASHO) (*1*). As shown in table 5, these samples were tested by the Division of Materials and Tests, *test data* [1]—Continued

Mechanical analysis [3]									Liquid Limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—						AASHO [5]	Unified [6]
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 50[4] (0.297 mm.)	No. 60[4] (0.250 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
--------	--------	--------	100	99	95	65	42	38	44	18	A-7-6(12)	ML-CL.
--------	--------	--------	--------	100	97	67	42	36	51	24	A-7-6(16)	MH-CH.
--------	--------	--------	--------	100	96	61	35	29	42	20	A-7-6(12)	CL.
--------	--------	--------	--------	100	97	74	42	36	48	19	A-7-6(13)	ML-CL.
--------	--------	--------	--------	100	97	73	45	39	57	31	A-7-6(19)	CH.
--------	--------	--------	--------	100	97	68	40	35	49	26	A-7-6(16)	CL.
--------	--------	--------	--------	100	97	70	40	35	45	20	A-7-6(13)	ML-CL.
--------	--------	--------	--------	100	98	73	43	39	55	27	A-7-6(18)	MH-CH.
--------	--------	--------	--------	100	97	62	37	32	47	24	A-7-6(15)	CL.
--------	--------	--------	--------	100	97	66	35	30	37	12	A-6(9)	ML-CL.
--------	--------	--------	--------	100	97	72	41	36	50	23	A-7-6(15)	ML-CL.
--------	--------	--------	--------	100	97	62	36	30	44	20	A-7-6(13)	CL.
--------	--------	100	--------	97	87	--------	32	--------	39	12	A-6(9)	ML-CL.
--------	--------	100	--------	98	87	--------	37	--------	46	22	A-7-6(14)	CL.
--------	--------	--------	--------	100	82	--------	37	--------	51	27	A-7-6(17)	CH.
--------	--------	100	--------	98	89	--------	32	--------	41	12	A-7-6(9)	ML.
--------	--------	100	--------	99	89	--------	39	--------	53	24	A-7-6(16)	MH-CH.
--------	--------	100	--------	99	84	--------	33	--------	46	23	A-7-6(14)	CL.

tural classes for soils. The percentages of 0.02 millimeter and 0.002 millimeter size particles are not determined by the Nebraska Department of Roads.

[4] Analyses made by Nebraska Department of Roads report percentage passing No. 50 sieve, since that department does not use the No. 60 sieve. The percentage passing the No. 60 sieve is reported for all samples analyzed by the Bureau of Public Roads.

[5] Based on "Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1, ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes." AASHO Designation: M 145-49(*1*).

[6] Based on "The Unified Soil Classification System." Technical Memorandum No. 3-357, Waterways Experiment Station, Corps of Engineers, March 1953, rev. 1957(*14*).

[7] Tested by Bureau of Public Roads.

[8] Flocculation occurred because of the presence of calcium sulfate; impossible to use hydrometer method in mechanical analysis.

Nebraska Department of Roads and the U.S. Department of Commerce, Bureau of Public Roads.

Samples tested by the Nebraska Department of Roads were obtained and tested during soil surveys made for highway projects in the county. Each soil was sampled by natural horizons, but the terminology used by the Nebraska Department of Roads in describing each horizon differs somewhat from that used by the Soil Conservation Service. Therefore, the horizons of the samples taken by the Nebraska Department of Roads are described as upper layer, middle layer, and lower layer, or parent material. However, the upper layer is approximately equivalent to the A horizon, the middle layer is equivalent to the B horizon, and the lower layer, or parent material, is equivalent to the C horizon. The meanings of the horizon symbols (A, B, and C), generally used by soil scientists, are explained further in the Glossary.

689-405—64——4

The soils shown in table 5 were sampled in one or more locations. The test data for the soils sampled in only one location indicate the engineering characteristics of the soil at that specific location. It must be recognized that there may be variations in the physical test characteristics of this soil at other locations in the county. Even for those soils sampled in more than one location, the test data probably do not show the maximum range in characteristics of materials that may occur.

The engineering soil classifications in table 5 are based upon data obtained by mechanical analysis and by tests to determine liquid limit and plasticity index. The mechanical analysis was made by combined use of sieve and hydrometer methods.

The tests for liquid limit and plastic limit measure the effect of water on the consistency of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a solid to semisolid or plastic state. As the moisture content is further increased, the material changes from the plastic to a liquid state. The plastic limit is the moisture content, expressed as a percentage of the oven-dry weight of the soil, at which the soil material passes from a solid to a plastic state. The liquid limit is the moisture content at which the material passes 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 in a plastic condition. Some silty and sandy soils are nonplastic, that is they will not become plastic at any moisture content.

Table 5 also gives moisture-density relationships (compaction data) for a number of the soils tested. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the dry density of the compacted material will increase until the optimum moisture content is reached;

TABLE 6.—*Brief description of the soils*

Map symbol	Soil	Description of soil and site					Depth from surface
		Position	Parent material	Runoff	Depth to water table	Depth to sand or sand and gravel	
					Feet	*Feet*	*Inches*
Au	Albaton clay	Bottom lands	Clayey alluvium	Slow	2–5	4–8	0–12 12–40 40–50+
Ab	Albaton silt loam	Bottom lands	Clayey alluvium	Slow	2–5	4–8	0–12 12–40 40–50+
Bs	Belfore silty clay loam	Uplands	Peorian loess	Slow	(1)	(2)	0–15 15–40 40–60+
BdC2 BdD2	Burchard clay loam, 7 to 12 percent slopes, eroded.[3] Burchard clay loam, 12 to 18 percent slopes, eroded.[3]	Uplands	Glacial till	Moderate to rapid.	(1)	(2)	0–10 10–36 36–60+
Cg	Carr fine sandy loam	Bottom lands	Sandy alluvium	Slow	2–5	2–4	0–10 10–30 30–50+
Cs	Cass fine sandy loam	Bottom lands	Sandy alluvium	Slow	3–10	3–5	0–15 15–40 40–60+
Cm	Cass loam	Bottom lands	Sandy alluvium	Slow	3–10	3–5	0–15 15–40 40–60+
CfC3 CfD3 CfE CfE3	Crofton silt loam, 7 to 12 percent slopes, eroded.[3] Crofton silt loam, 12 to 18 percent slopes, eroded.[3] Crofton silt loam, 18 to 30 percent slopes.[3] Crofton silt loam, 18 to 30 percent sloped, eroded.[3]	Uplands	Peorian loess	Rapid to very rapid.	(1)	(2)	0–6 6–12 12–60
GL	Gullied land, Judson materials	Bottom lands	Colluvial-alluvial silts.	Very rapid	(1)	(4)	0–60

See footnotes at end of table.

after that the dry density decreases with an increase in moisture. The highest dry density obtained in the compaction test is the maximum dry density. Moisture-density data are important in earthwork for, as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

Engineering properties of the soils

Engineering information about each soil in the county is given in table 6 in this section. For more detailed information about the soils, it may be necessary to refer elsewhere in this report, particularly to the section "Descriptions of the Soils." Information on the geology of this county is under "Parent Material" in the section "Genesis, Classification, and Morphology of Soils."

Table 6 shows brief descriptions of the soils in Washington County and estimates of some of their physical properties. The engineering test data in table 5, information taken from the rest of the soil survey, and knowledge of the individual soils in the county were used as a basis for describing the soils in this table, estimating their physical properties, and estimating the ranges in percentage passing the various sieves. The AASHO and Unified classifications were made by using the combined information.

and estimated physical properties

Classification			Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
AASHO	Unified	USDA texture	No. 4	No. 10	No. 200			
						Inches per hour	*Inches per inch of soil*	
A-7-6	CH	Clay	100	100	95–100	0. 05–0. 20	0. 18	High.
A-7-6	CH	Clay	100	100	95–100	0. 05–0. 20	0. 18	High.
A-2 to A-6	SM to SC	Stratified sandy materials.	95–100	80–95	30–50	2. 5–5. 0	0. 15 to 0. 17	None to low.
A-4 to A-6	ML to CL	Silt loam	100	100	90–100	0. 80–2. 5	0. 16	Low to moderate.
A-7-6	CH	Clay	100	100	95–100	0. 05–0. 20	0. 18	High.
A-2 to A-6	SM to SC	Stratified sandy materials.	95–100	80–95	30–50	2. 5–5. 0	0. 15 to 0. 17	None to low.
A-4 to A-7-6	ML to CL	Silty clay loam	100	100	95–100	0. 20–0. 80	0. 17	Low to moderate.
A-6 or A-7-6	CL or CH	Silty clay loam to silty clay.	100	100	95–100	0. 20–0. 80	0. 17	Moderate to high.
A-6 or A-7-6	CL	Silty clay loam	100	100	95–100	0. 20–0. 80	0. 17	Moderate.
A-6 or A-7-6	CL or CH	Clay loam	100	100	95–100	0. 20–0. 80	0. 17	Moderate to high.
A-6 or A-7-6	CL or CH	Clay loam	100	100	95–100	0. 20–0. 80	0. 17	Moderate to high.
A-6 or A-7-6	CL or CH	Clay loam	100	100	95–100	0. 20–0. 80	0. 17	Moderate to high.
A-2 to A-6	SM or SC	Fine sandy loam	100	95–100	30–50	2. 5–5. 0	0. 15	None to low.
A-2 to A-6	SM or SC	Fine sandy loam	100	95–100	30–50	2. 5–5. 0	0. 15	None to low.
A-2 to A-6	SM to SC	Very fine sandy loam to sand.	100	50–90	15–50	2. 5–10. 0	0. 06 to 0. 16	None to low.
A-2 to A-6	SM or SC	Fine sandy loam	100	95–100	30–50	2. 5–5. 0	0. 15	None to low.
A-2 to A-6	SM or SC	Fine sandy loam	100	85–100	30–50	2. 5–5. 0	0. 15	None to low.
A-2 or A-3	SW–SM	Sand	100	60–95	5–10	5. 0–10. 0	0. 06	None.
A-4 or A-6	ML	Loam	100	95–100	50–80	0. 80–2. 5	0. 16	Low to moderate
A-2 to A-6	SM or SC	Fine sandy loam	100	85–100	30–50	2. 5–5. 0	0. 15	None to low.
A-2 or A-3	SW–SM	Sand	95–100	60–95	5–10	5. 0–10. 0	0. 06	None.
A-4 or A-6	ML to CL	Silt loam	100	95–100	95–100	0. 80–2. 5	0. 16	Low to moderate.
A-4 or A-6	ML to CL	Silt loam	100	95–100	95–100	0. 80–2. 5	0. 16	Low to moderate.
A-4	ML	Silt loam	100	95–100	95–100	0. 80–2. 5	0. 16	Low to moderate.
A-4 or A-6	ML to CL	Silt loam	100	95–100	85–100	0. 80–2. 5	0. 16	Low to moderate.

TABLE 6.—*Brief description of the soils and*

Map symbol	Soil	Description of soil and site: Position	Parent material	Runoff	Depth to water table	Depth to sand or sand and gravel	Depth from surface
					Feet	*Feet*	*Inches*
He	Haynie silt loam	Bottom lands	Silty and sandy alluvium.	Slow	2–6	(4)	0–10 10–20 20–60+
JuA JuB	Judson silt loam, 1 to 3 percent slopes.[3] Judson silt loam, 3 to 7 percent slopes.[3]	Bottom lands and colluvial slopes.	Colluvial-alluvial silts.	Slow to moderate.	10–20	(4)	0–20 20–30 30–60+
Ke	Kennebec silt loam	Bottom lands	Silty alluvium	Slow	10–20	(4)	0–15 15–30 30–60+
LC	Lamoure [5]-Colo [5] silty clay loams	Bottom lands	Silty and clayey alluvium.	Slow	2–10	(4)	0–16 16–36 36–60+
Le	Leshara silt loam	Bottom lands	Silty alluvium	Slow	3–15	5–20	0–24 24–48 48–60+
2Le	Leshara soils, clayey substrata	Bottom lands	Silty alluvium	Slow	3–15	5–20	0–24 24–48 48–60+
LLu	Luton and Leshara [5] clays	Bottom lands	Clayey alluvium	Slow	5–15	(4)	0–20 20–40 40–60+
Ls	Luton silty clay loam	Bottom lands	Clayey alluvium	Slow	5–15	(4)	0–20 20–40 40–60+
Lt	Luton silt loam, overwash	Bottom lands	Silty and clayey alluvium.	Slow	5–15	(4)	0–15 15–30 30–60+
Lu	Luton clay	Bottom lands	Clayey alluvium	Slow	5–15	(4)	0–15 15–25 25–60+
Mc	McPaul silt loam	Bottom lands	Colluvial-alluvial silts.	Slow	5–20	(4)	0–20 20–30 30–60+
Mn MnA MnB MnB2 MnC MnC2	Monona silt loam, 0 to 1 percent slopes.[3] Monona silt loam, 1 to 3 percent slopes.[3] Monona silt loam, 3 to 7 percent slopes.[3] Monona silt loam, 3 to 7 percent slopes, eroded.[3] Monona silt loam, 7 to 12 percent slopes.[3] Monona silt loam, 7 to 12 percent slopes, eroded.[3]	Uplands	Peorian loess	Slow to rapid	(1)	(2)	0–12 12–36 36–60+
MCD MCD3	Monona-Crofton silt loams, 12 to 18 percent slopes.[6] Monona-Crofton silt loams, 12 to 18 percent slopes, eroded.[6]						

See footnotes at end of table.

estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
AASHO	Unified	USDA texture	No. 4	No. 10	No. 200			
						Inches per hour	*Inches per inch of soil*	
A-4 or A-6	ML to CL	Silt loam	100	90-100	80-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	90-100	80-100	0.80-2.5	0.16	Low to moderate.
A-4	ML	Stratified silty materials	100	90-100	80-100	0.80-5.0	0.15 to 0.16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-6 or A-7-6	CL or CH	Silty clay loam	100	100	95-100	0.20-0.80	0.17	Moderate to high.
A-4 or A-6	ML or CL	Silt loam	100	95-100	90-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	95-100	90-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	95-100	90-100	0.80-2.5	0.16	Low to moderate.
A-6 or A-7-6	CL	Silty clay loam	100	100	95-100	0.02-0.80	0.17	Moderate.
A-6 or A-7-6	CL	Silty clay loam	100	100	95-100	0.20-0.80	0.17	Moderate.
A-6 or A-7-6	CL	Silty clay loam	100	100	95-100	0.05-0.20	0.18	Moderate.
A-4 or A-6	ML	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-2 to A-6	SM or SC	Very fine sandy loam	100	90-100	30-50	0.80-2.5	0.16	None to low.
A-2 to A-6	SM or SC	Stratified sandy materials.	100	50-90	20-50	2.5-5.0	0.15 to 0.17	None to low.
A-4 or A-6	ML to CL	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-6 or A-7-6	CL or CH	Silty clay to clay	100	100	100	0.05-0.20	0.18	Moderate to high.
A-2 to A-6	SM or SC	Stratified sandy materials.	100	50-90	20-50	2.5-5.0	0.15 to 0.17	None to low.
A-7	CH	Clay	100	100	95-100	0.05-0.20	0.18	High.
A-4 or A-6	ML to CL	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-2 or A-6	SM or SC	Stratified sandy materials.	100	50-90	20-50	2.5-5.0	0.15	None to low.
A-6 or A-7	CL or CH	Silty clay loam	100	100	95-100	0.20-0.80	0.17	Moderate to high.
A-6 or A-7	CL or CH	Silty clay	100	100	95-100	0.05-0.20	0.18	Moderate to high.
A-6 or A-7	CL or CH	Silty clay	100	100	95-100	0.05-0.20	0.18	Moderate to high.
A-4 or A-6	ML	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-6 or A-7	CL or CH	Silty clay	100	100	95-100	0.05-0.20	0.18	Moderate to high.
A-7	CH	Clay	100	100	95-100	0.05-0.20	0.18	High.
A-7	CH	Clay	100	100	95-100	0.05-0.20	0.18	High.
A-7	CH	Clay	100	100	95-100	0.05-0.20	0.18	High.
A-7	CH	Clay	100	100	95-100	0.05-0.20	0.18	High.
A-4 or A-6	ML	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	ML to CL	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	ML to CL	Very fine sandy loam to silt loam.	100	90-100	80-95	0.80-2.5	0.16	Low to moderate.
A-4	ML	Silt loam	100	100	95-100	0.80-2.5	0.16	Low.
A-4 to A-7-6	ML to CL	Silt loam	100	100	95-100	0.80-2.5	0.16	Low to moderate.
A-4 or A-6	CL	Silt loam	100	95-100	90-100	0.80-2.5	0.16	Low to moderate.
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TABLE 6.—*Brief description of the soils and*

Map symbol	Soil	Description of soil and site: Position	Parent material	Runoff	Depth to water table	Depth to sand or sand and gravel	Depth from surface
					Feet	*Feet*	*Inches*
MMB	Moody and Marshall soils, 3 to 7 percent slopes.[3]	Uplands	Peorian loess	Moderate to rapid.	([1])	([2])	0–12
MMB2	Moody and Marshall soils, 3 to 7 percent slopes, eroded.[3]						12–36
							36–60
MMC	Moody [5] and Marshall soils, 7 to 12 percent slopes.[3]	Uplands	Peorian loess	Moderate to rapid.	([1])	([2])	0–10
MMC2	Moody and Marshall soils, 7 to 12 percent slopes, eroded.[3]						10–36
							36–60
NCC3	Nora [5] and Crofton soils, 7 to 12 percent slopes, severely eroded.[3]	Uplands	Peorian loess	Moderate to rapid.	([1])	([2])	0–8 8–24 24–60
NCD3	Nora and Crofton soils, 12 to 18 percent slopes, severely eroded.[3]						
NC3	Nora and Marshall soils, 7 to 12 percent slopes, severely eroded.[3 7]	----------	----------	----------	----------	----------	----------
ND2	Nora and Marshall soils, 12 to 18 percent slopes, eroded.[3 7]						
ND3	Nora and Marshall soils, 12 to 18 percent slopes, severely eroded.[3 7]						
NMD2	Nora and Moody soils, 12 to 18 percent slopes, eroded.[8]	----------	----------	----------	----------	----------	----------
OH	Onawa and Haynie [5] silty clay loams.	Bottom lands	Clayey and sandy alluvium.	Slow	2–6	4–8	0–20 20–30 30–60+
Ou	Onawa clay	Bottom lands	Clayey and sandy alluvium.	Slow	2–6	4–8	0–20 20–30 30–60+
Ra	Rauville soils	Bottom lands	Silty and clayey alluvium.	Slow	1–3	([4])	0–15 15–25 25–60
Rw	Riverwash	Bottom lands	Sandy alluvium	Slow	1–3	0–3	0–60
Sv	Salix [5] and Volin [5] silt loams	Bottom lands	Silty alluvium	Slow	5–15	5–10	0–12 12–20 20–60+
Sg	Sarpy loamy fine sand	Bottom lands	Sandy alluvium	Slow	2–10	2–4	0–10 10–20 20–60+
Sl	Sarpy loam	Bottom lands	Sandy alluvium	Slow	2–10	2–4	0–10 10–20 20–60

See footnotes at end of table.

estimated physical properties—Continued

Classification			Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
AASHO	Unified	USDA texture	No. 4	No. 10	No. 200			
						Inches per hour	*Inches per inch of soil*	
A-7-6	ML or ML-CL.	Silty clay loam	100	100	95-100	0. 20-0. 80	0. 17	Moderate.
A-7-6	ML or ML-CL.	Silty clay loam	100	100	95-100	0. 20-0. 80	0. 17	Moderate.
A-7-6	ML or ML-CL.	Silt loam	100	95-100	90-100	0. 20-2. 5	0. 16	Moderate.
A-7-6	ML or ML-CL.	Silty clay loam	100	100	95-100	0. 20-0. 80	0. 17	Moderate.
A-7-6	ML or ML-CL.	Silty clay loam	100	100	95-100	0. 20-0. 80	0. 17	Moderate.
A-7-6	ML or ML-CL.	Silty clay loam	100	100	90-100	0. 20-0. 80	0. 17	Moderate.
A-4	ML to CL	Silty clay loam	100	100	80-95	0. 20-0. 80	0. 17	Low to moderate.
A-4 to A-7-6	ML to CL	Silty clay loam	100	100	80-90	0. 20-0. 80	0. 16	Low to moderate.
A-4 to A-7-6	ML to CL	Silt loam	100	95-100	80-90	0. 20-2. 5		Low to moderate.
A-6 or A-7-6	CL or CH	Silty clay loam	100	98-100	95-100	0. 20-0. 80	0. 17	Moderate to high.
A-2 to A-6	SM to SC	Very fine sandy loam	100	95-100	30-50	0. 80-2. 5	0. 16	None to low.
A-2 to A-6	SM to SC	Stratified sandy materials.	100	50-90	15-50	2. 5-10. 0	0. 15	None to low.
A-7-6	CH	Clay	100	100	95-100	0. 05-0. 20	0. 18	High.
A-2 to A-6	SM to SC	Very fine sandy loam	100	95-100	30-50	0. 80-2. 5	0. 16	None to low.
A-2 to A-6	SM to SC	Stratified sandy materials.	100	50-90	15-50	2. 5-10. 0	0. 15	None to low.
A-7-6	CH	Clay	100	100	95-100	0. 05-0. 20	0. 18	High.
A-6 or A-7-6	CL or CH	Silty clay	100	100	95-100	0. 05-0. 20	0. 18	Moderate to high.
A-4 or A-6	ML or CL	Silt loam	100	98-100	95-100	0. 80-2. 5	0. 16	Low to moderate.
A-2 or A-3	SW or SM	Stratified sandy materials.	98-100	10-50	5-15	2. 5-10. 0	0. 10 to 0. 15	None.
A-4 or A-6	ML or CL	Silt loam	100	90-100	80-100	0. 80-2. 5	0. 16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	90-100	80-100	0. 80-2. 5	0. 16	Low to moderate.
A-4 or A-6	ML or CL	Silt loam	100	90-100	80-100	0. 80-2. 5	0. 16	Low to moderate.
A-2 or A-4	SM	Loamy fine sand	100	80-100	20-40	5. 0-10. 0	0. 10	None to low.
A-2 or A-4	SM	Loamy fine sand	100	80-100	20-40	5. 0-10. 0	0. 10	None to low.
A-2 or A-4	SW or SP to SM.	Fine sand	95-100	60-95	5-15	10+	0. 06	None to low.
A-4 or A-6	ML	Loam	100	90-100	50-80	0. 80-2. 5	0. 16	Low to moderate.
A-2 to A-4	SM	Loamy fine sand	100	80-100	20-40	5. 0-10. 0	0. 10	None to low.
A-2 or A-3	SW or SP to SM.	Fine sand	95-100	60-95	5-15	10+	0. 06	None.

TABLE 6.—*Brief description of the soils and*

Map symbol	Soil	Description of soil and site					Depth from surface
		Position	Parent material	Runoff	Depth to water table	Depth to sand or sand and gravel	
					Feet	*Feet*	*Inches*
Sh	Sharpsburg silty clay loam, 0 to 1 percent slopes.	Uplands	Loess	Slow to rapid	(1)	(2)	0–15 15–45 45–60+
SMA	Sharpsburg and Marshall soils, 1 to 3 percent slopes.[9]						
SMB	Sharpsburg and Marshall soils, 3 to 7 percent slopes.[9]						
SMB2	Sharpsburg and Marshall soils, 3 to 7 percent slopes, eroded.[9]						
SMC	Sharpsburg and Marshall soils, 7 to 12 percent slopes.[9]						
SMC2	Sharpsburg and Marshall soils, 7 to 12 percent slopes, eroded.[9]						
S	Spoil banks	Bottom lands	Alluvium	Moderate to rapid.	5–15	(10)	(10)
StD2	Steinauer soils, 12 to 18 percent slopes, eroded.	Uplands	Glacial till	Rapid to very rapid.	(1)	(2)	0–6 6–10 10–60

[1] The water table is extremely deep in all upland soils and in some bottom-land soils. It is not shown here as it is not considered significant in the interpretation of engineering properties.
[2] Normally, sand or sand and gravel are not present.
[3] Soils grouped within the brace are nearly uniform in the properties listed, except in slope and degree of erosion indicated by the soil names, and in runoff. The range given for runoff covers all the sloping or eroded phases listed in this column.
[4] Sand or sand and gravel may occur at a depth below 8 feet.
[5] In this undifferentiated unit or complex, the description, classification, and properties are for the soil footnoted. If both soils of the undifferentiated unit or complex are footnoted, they are similar in description, classification, and properties and estimates have been made on this basis.

The estimated range in percentage passing sieves Nos. 4, 10, and 200, as shown in table 6, reflects the normal range for a given soil. The texture (grain size) of any soil varies considerably, especially that of alluvial (water-deposited) materials. It should not, therefore, be assumed that all samples of a given soil will fall within the range shown in table 6, nor that the engineering classification will always be the same as shown.

Runoff rates vary extremely in the county. The soils are mostly fine grained, and the infiltration rates are relatively low. Therefore, variations of runoff rates, as shown in table 6, may reflect topographic differences as well as soil characteristics that affect runoff.

The column in table 6 headed "Permeability" refers to the rate of movement of water through soil material in its undisturbed state. Permeability depends largely on soil texture and structure. The permeability rating of a soil, as shown in this table, is based on the following classification:

Inches per hour	*Rating*
0.05 to 0.2	Slow.
.2 to .8	Moderately slow.
.8 to 2.5	Moderate.
2.5 to 5.0	Moderately rapid.
5.0 to 10.0	Rapid.
Over 10	Very rapid

In the column headed "Available water capacity" are estimates, in inches per inch of soil, of the water available for plant consumption. This water is held in the range between the field capacity and wilting point.

In general, the texture of a soil indicates its shrink-swell potential. In table 6, the shrink-swell potential has been estimated for plastic silts and clays as *high*, and for nonplastic soils that have no shrink-swell potential as *none*. *Low* or *moderate* ratings have been given intermediate soils with less silt and clay content or with low or moderate plasticity index ratings. Some of these soils, however, were rated *low* or *moderate* by comparisons with soils of known mechanical analysis or plasticity ratings.

The reaction (pH) of soils in this county generally ranges from 6.0 to 8.0 in the surface layer and from 7.0 to 8.5 in the subsurface layers. Salts in detrimental quantity occur only in relatively few locations and affect only small areas. Because of the small size of these areas, this condition is not considered significant in evaluating hazards of construction and maintaining engineering practices.

Dispersion is generally not a problem in this county, although a few, very small areas containing sodium salts have moderate dispersion. Because of the small size of these areas, this condition is not considered significant in evaluating hazards of construction and in maintaining engineering structures.

estimated physical properties—Continued

Classification			Percentage passing sieve—			Perme-ability	Available water capacity	Shrink-swell potential
AASHO	Unified	USDA texture	No. 4	No. 10	No. 200			
						Inches per hour	*Inches per inch of soil*	
A-4	ML or CL	Silty clay loam	100	100	95–100	0. 20–0. 80	0. 17	None to low.
A-4 or A-6	ML or CL	Silty clay loam	100	100	95–100	0. 20–0. 80	0. 17	Low to moderate.
A-6 or A-7-6	CL or CH	Silty clay loam	100	100	95–100	0. 20–0. 80	0. 17	Moderate to high.
(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)	(10)
A-6 or A-7-6	CL	Clay loam	95–100	85–95	75–90	0. 20–0. 80	0. 17	Moderate.
A-6 or A-7-6	CL	Clay loam	95–100	85–95	75–90	0. 20–0. 80	0. 17	Moderate.
A-6 or A-7-6	CL or CH	Clay loam	95–100	85–95	75–90	0. 20–0. 80	0. 17	Moderate to high.

[6] Properties of Monona soils are those given for the Monona silt loam mapping units; properties of the Crofton soils are those given for the Crofton silt loam mapping units.

[7] Properties of Nora soils are given for the Nora and Crofton mapping units; properties of Marshall soils are given for the Moody and Marshall mapping units.

[8] Properties of Nora soils are those given for the Nora and Crofton mapping units; properties of Moody soils are those given for the Moody and Marshall mapping units.

[9] Properties of the Sharpsburg soils are those given for Sharpsburg silty clay loam, 0 to 1 percent slopes; properties of the Marshall soils are those given for the Moody and Marshall mapping units.

[10] Classification and properties not estimated because of variable characteristics of this mapping unit.

Engineering interpretations

Table 7 gives an interpretation of some of the engineering properties of soils in Washington County. This table lists individual soil features that affect highways and conservation engineering structures. Some of the hazards and problems related to construction and maintenance are also given.

The adaptability of soils of the county to winter grading for highways varies from year to year, depending on the moisture content of the soil and the temperatures during winter. Because of the predominance of fine-grained soils with a relatively high content of silt and clay, few soils in the county that receive normal moisture in fall are adapted to winter grading. The bottom-land soils are subject to occasional flooding.

The ratings given in table 7 for suitability of soil material for topsoil, sand, and gravel apply only to Washington County. Many of the soils are rated *poor* or *fair* as a source of topsoil because they are eroded, are low in content of organic matter or natural fertility, or have heavy and sticky topsoil that is difficult to handle or work. The soils given ratings that indicate that they are a possible source of sand or gravel may require extensive exploring to find material that will meet the requirements. Soils rated *good* as a source of sand or gravel may still require extensive exploring to find material that will meet requirements.

Under the columns headed "Road subgrade," the soils have been rated for use as subgrade for paved roads (bituminous or concrete) and for gravel roads.

The ratings given in the column headed "Paved" refer to the upper part of the subgrade of the roadbed for bituminous and concrete pavement. Sands, when properly confined, are a good subgrade material for roads of this type. The soil material was rated *good* for road subgrade (paved) if the AASHO classification was A–1, A–2, or A–3. If the soil material in the subgrade is silt and clay, the AASHO classification ranges from A–4 to A–7–6 and the rating is *fair* for material classified as A–4 and *poor* for that classified as A–7–6.

In the column headed "Gravel," the rating refers to that part of the subgrade that receives the gravel surfacing. Since sand is noncohesive, it does not provide a stable surface. All soils classified A–3 and those classified A–1 and A–2 that do not have adequate plasticity are rated *poor*. Some soils classified A–1 and A–2 that have adequate plasticity may be rated *good to fair*. Silt or clay soils that are classified A–4 to A–7–6 are usually acceptable for use in the part of the upper subgrade that receives a gravel surfacing and are rated *good* or *fair*.

In the column headed "Road fill," ratings for the soils were based on the same criteria as the ratings for the soils for subgrade under bituminous or concrete pavement. The ratings in all three columns (*Paved*, *Gravel*, *Road*

TABLE 7.—*Engineering*

Soil series and map symbols	Engineering classification		Suitability						Soil features affecting—
			As source of—			Of soil material for—			
	AASHO	Unified	Topsoil	Sand	Sand and gravel	Road subgrade: Paved	Road subgrade: Gravel	Road fill	Highway location
Albaton (Au, Ab).	A-4 to A-7-6 (surface soil and subsoil) over A-2 to A-6 (substratum).	ML to CH (surface soil) over CH (subsoil) over SM to SC (substratum).	Poor to fair.	Fair to poor.	(1)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; water table may rise to near surface; 4 to 7 feet of fill required; slopes easily eroded; occasionally flooded.
Belfore (Bs)	A-4 to A-7-6 (surface soil) over A-6 or A-7-6 (subsoil and substratum).	ML to CL (surface soil) over CL or CH (subsoil) over CL (substratum).	Good	(3)	(3)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.
Burchard (BdC2, BdD2).	A-6 or A-7-6 (surface soil, subsoil, and substratum).	CL or CH (surface soil) over CL or CH (subsoil) over CL or CH (substratum).	Fair	(3)	(3)	Poor	Good	Poor	Moderate to high susceptibility to frost action; slopes erodible.
Carr (Cg)	A-2 to A-6 (surface soil, subsoil, and substratum).	SM or SC (surface soil) over SM or SC (subsoil) over SM to SC (substratum).	Fair	Fair (fine sand).	(1)	Good to fair.	Good to poor.	Good to fair.	Low to high susceptibility to frost action; water table may rise to near surface; 4 to 7 feet of fill may be required; infrequent flooding.
Cass (Cs, Cm).	A-2 to A-6 (surface soil and subsoil) over A-2 or A-3.	SM or SC or ML (surface soil and subsoil) over SW-SM (substratum).	Good	Fair to poor.	Poor	Good to fair.	Fair to poor.	Good to fair.	Low to high susceptibility to frost action; water table may rise to near surface; 4 to 7 feet of fill may be required.
Crofton (CfC3, CfD3, CfE, CfE3).	A-4 or A-6 (surface soil and subsoil); over A-4 (substratum).	ML to CL (surface soil and subsoil); over ML (substratum).	Good to fair.	(3)	(3)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.

See footnotes at end of table.

interpretations

Soil features affecting—Continued							
Foundations	Dikes and levees	Low dams		Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
		Reservoir	Embankment				
Good to poor bearing value; subject to piping.	Erodible; may need slope protection.	[2]	[2]	Subject to occasional flooding; seasonally high water table; slow permeability.	High water-holding capacity; adequate drainage necessary.	[2]	[2].
Fair to poor bearing value.	[2]	[2]	[2]	[2]	High water-holding capacity; slow intake rate.	Moderately erodible.	Moderately erodible.
Fair to poor bearing value.	[2]	[4]	Good to fair stability; flat slopes may be required; impervious.	[2]	High water-holding capacity; slow intake rate.	Moderately to highly erodible.	Highly erodible where subsoil is exposed; may have maintenance and vegetative problems.
Good to poor bearing value, depending on density; subject to piping.	Erodible; moderate to low piping hazard; may require flat slopes.	[2]	[2]	Subject to occasional flooding; moderately good drainage.	Moderate water-holding capacity; adequate drainage necessary.	[2]	Moderately to highly erodible; may have vegetative problem.
Good to poor bearing value; subject to piping.	Erodible; moderate to low piping hazard; flat slopes may be required.	[2]	[2]	Subject to occasional flooding.	Moderate water-holding capacity; adequate drainage necessary.	Field terraces not applicable; maintenance costs of diversion terraces may be high if cut into subsoil.	Moderately to highly erodible; low in fertility.
Very poor bearing value; subject to severe piping.	[2]	Seepage may be a hazard.	Poor to good stability; poor to good resistance to piping.	[2]	High water-holding capacity; slow intake rate.	Highly erodible; steeper and more irregular slopes make structure impractical.	Highly erodible; low in fertility; maintenance costs may be excessive.

TABLE 7.—*Engineering*

Soil series and map symbols	Engineering classification		Suitability						Soil features affecting—
			As source of—			Of soil material for—			
	AASHO	Unified	Topsoil	Sand	Sand and gravel	Road subgrade		Road fill	Highway location
						Paved	Gravel		
Gullied land (GL).	A–4 or A–6	ML to CL	Poor	(1)	(1)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.
Haynie (Hc)	A–4 or A–6 (surface soil and subsoil); over A–4 (substratum).	ML to CL (surface soil and (subsoil); tover ML substratum).	Good to fair.	(1)	(1)	Poor to fair.	Good	Fair to poor.	Moderate to high susceptibility to frost action; water table may be high; slopes erodible.
Judson JuA, JuB).	A–4 or A–6 (surface soil and subsoil); over A–6 or A–7–6 (substratum).	ML or CL (surface soil and subsoil); over CL or CH (substratum).	Good	(1)	(1)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; may be subject to occasional overflow; slopes erodible.
Kennebec (Ke).	A–4 or A–6 (surface soil, subsoil, and substratum).	ML or CL (surface soil, subsoil, and substratum).	Good	(1)	(1)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.
Lamoure-Colo [5] (LC).	A–6 or A–7–6 (surface soil, subsoil, and substratum).	CL (surface soil, subsoil, and substratum).	Good	(1)	(1)	Poor	Good	Poor	Moderate to high susceptibility to frost action; water table may rise to near surface; 4 to 7 feet of fill required; slopes erodible.
Leshara (Le, 2Le).	A–4 or A–6 (surface soil); over A–2 to A–7–6 (subsoil); over A–2 to A–6 (substratum).	ML to CL (surface soil); over SM to CH (subsoil); over SM or SC (substratum).	Good	(1)	(1)	Fair to poor.	Good to fair.	Fair to poor.	Moderate to high susceptibility to frost action; water table may be high; 4 to 7 feet fill may be required; slopes erodible.
Luton and Leshara (LLu).	A–4 to A–7–6 (surface soil and subsoil); over A–2 to A–7–6 (substratum).	ML to CH (surface soil and subsoil); over SM to CH (substratum).	(6)	(6)	(6)	(6)	(6)	(6)	(6)

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued							
Foundations	Dikes and levees	Low dams		Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
		Reservoir	Embankment				
Poor to good bearing value; may have piping hazard.	Slopes erodible; low to moderate piping hazard.	Seepage may be a hazard.	Piping may be a hazard.	(2)	(2)	(2)	Erodible; necessary steep slopes may make construction and maintenance costs excessive.
Poor to fair bearing value; piping hazard.	Slopes erodible; piping may be a problem.	(2)	(2)	Subject to occasional flooding; seasonally high water table; moderately slow permeability.	Moderate to high water-holding capacity; slow intake rate; adequate drainage necessary.	(2)	Erodible; if vegetated, fertility may be a problem.
Fair to poor bearing value.	Slopes erodible; piping may be a problem.	Seepage may be a moderate hazard.	Poor to good stability.	Subject to occasional flooding.	High water-holding capacity.	Field terraces generally not applicable.	Highly erodible.
Very poor to fair bearing; may have piping hazard.	(2)	Seepage may be a moderate hazard.	Poor to good stability.	Moderately slow permeability.	High water-holding capacity.	Field terraces generally not applicable; diversion terraces are erodible.	Erodible; fertile; supports good vegetation.
Good to poor bearing value.	Moderately erodible slopes.	(4)	(4)	Seasonally high water table; slow surface and internal drainage; outlets for drains may be a problem.	High water-holding capacity; slow intake rate; adequate drainage necessary.	Field terraces generally not applicable; diversion terraces are erodible.	Moderately erodible.
Good to poor bearing value; low to high piping hazard.	Piping may be a serous hazard; slopes erodible.	Seepage may be a hazard if excavated below 3 feet.	Fair stability; piping may be a hazard.	Seasonally high water table; subject to occasional flooding; permeability is slow; poor surface drainage.	Moderate to high water-holding capacity; adequate drainage necessary.	(2)	Erodible.
(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6).

TABLE 7.—*Engineering*

Soil series and map symbols	Engineering classification		Suitability						Soil features affecting—
			As source of—			Of soil material for—			
						Road subgrade			
	AASHO	Unified	Topsoil	Sand	Sand and gravel	Paved	Gravel	Road fill	Highway location
Luton (Lu, Ls, Lt).	A-4 to A-7-6 (surface soil, subsoil, and substratum).	ML to CH (surface soil) over CL or CH (subsoil and substratum).	Fair to poor.	(1)	(1)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.
McPaul (Mc)	A-4 or A-6 (surface soil, subsoil, and substratum).	ML (surface soil) over ML to CL (subsoil and substratum).	Good	(1)	(1)	Fair to poor	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible; subject to frequent flooding.
Monona (Mn, MnA, MnB, MnB2, MnC, MnC2).	A-4 (surface soil); over A-4 to A-7-6 (subsoil); over A-4 or A-6 (substratum).	ML (surface soil); over ML or CL (subsoil); over CL (substratum).	Good	(3)	(3)	Fair to poor.	Good	Fair to poor.	Slopes erodible; moderate to high susceptibility to frost action.
Monona-Crofton (MCD, MCD3).	A-4 to A-6 (surface soil); over A-4 to A-7-6 (subsoil); over A-4 to A-6 (substratum).	ML to CL (surface soil, subsoil, and substratum).	Good to fair.	(3)	(3)	(6)	(6)	(6)	(6)
Moody and Marshall (MMB, MMB2, MMC, MMC2).	A-4 (surface soil); over A-7-6 (subsoil); over A-6 to A-7-6 (substratum).	ML (surface soil) over CH (subsoil, over CL (substratum).	Good	(3)	(3)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.
Nora and Crofton [5] (NCC3, NCD3).	A-4 to A-6 (surface soil); over A-4 to A-7-6 (subsoil and substratum).	ML to CL (surface soil, subsoil, and substratum).	Good to fair.	(3)	(3)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; slopes erodible.
Nora and Marshall [6] (NC3, ND2, ND3).	A-4 (surface soil); over A-6 to A-7-6 (subsoil and substratum).	ML (surface soil); over CL or CH (subsoil); over CL (substratum).	(6)	(6)	(6)	(6)	(6)	(6)	(6)

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued							
Foundations	Dikes and levees	Low dams		Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
		Reservoit	Embankment				
Poor to fair bearing value.	Slopes may be erodible.	(2)	Fair stability; may require flat slopes; impervious.	Slow surface and internal drainage.	High water-holding capacity.	Field terraces not applicable; highly erodible diversion terraces.	Soil highly erodible in deeper cuts; vegetation may be rank and maintenance costs may be excessive.
Very poor to good bearing value; may have piping hazard.	May require flat slopes; piping may be a hazard.	Seepage may be a problem.	Fair to good stability; foundation drains may be required.	Subject to frequent flooding.	High water-holding capacity; flooding may be a problem.	Generally field terraces not applicable; erodible diversion terraces.	Erodible.
Good to poor bearing value.	(2)	Seepage may be a problem.	Fair to good stability.	(2)	High water-holding capacity; steeper slopes have erosion problem.	Highly erodible.	Highly erodible; maintenance costs may be excessive on steeper slopes.
(6)	(6)	(6)	(6)	(6)	(6)	Highly erodible; irregular topography may make impractical.	Highly erodible; maintenance costs may be excessive on steeper slopes.
Good to poor bearing value.	(2)	Seepage is a minor problem.	Fair to good stability; flat slopes may be required; impervious.	(2)	High water-holding capacity; steep slopes cause erosion hazard.	Moderate to highly erodible; maintenance may be excessive on steeper slopes.	Highly erodible; where subsoil is exposed, maintenance costs may be high.
Very poor to good bearing value; may have piping hazard.	(2)	Seepage may be moderate problem in Crofton series.	Poor to good stability; foundation drains may be required.	(2)	High water-holding capacity; erosion problem on steep slopes.	Highly erodible; construction and maintenance costs may be excessive on steeper slopes.	Highly erodible; maintenance costs may be excessive.
(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6).

TABLE 7.—*Engineering*

Soil series and map symbols	Engineering classification		Suitability						Soil features affecting—
			As source of—			Of soil material for—			
	AASHO	Unified	Topsoil	Sand	Sand and gravel	Road subgrade		Road fill	Highway location
						Paved	Gravel		
Nora and Moody [6] (NMD2).	A-4 (surface soil); over A-4 to A-7-6 (subsoil and substratum).	ML (surface soil); over CL or CH (subsoil) over CL (substratum).	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Onawa (Ou).	A-7-6 (surface soil); over A-2 to A-6 (subsoil and substratum).	CH (surface soil); over SM to SC (subsoil and substratum).	Poor	Poor	(1)	Fair to poor.	Good to fair.	Fair to poor.	Moderate to high susceptibility to frost action; slopes highly erodible; water may rise to near surface; 4 to 7 feet fill may be required; subject to frequent flooding.
Onawa and Haynie (OH).	A-4 to A-7-6 (surface soil); over A-2 to A-6 (subsoil and substratum).	ML to CH (surface soil); over SM to CL (subsoil); over SM to ML (substratum).	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Rauville (Ra).	A-7-6 (surface soil); over A-6 or A-7-6 (subsoil); over A-4 or A-6 (substratum).	CH (surface soil); over CL or CH (subsoil); over ML or CL (substratum).	Fair to poor.	(1)	(1)	Fair to poor.	Good	Fair to poor.	Moderate to high susceptibility to frost action; water table may rise to near surface; 4 to 7 feet fill may be required; slopes erodible.
Riverwash (Rw).	A-2 or A-3	SW or SM	Poor	Fair to poor.	(1)	Good	Poor	Good	Subject to frequent flooding; water table is high; high fill is necessary; slopes may be erodible.
Salix and Volin [5] (Sv)	A-4 or A-6 (surface soil, subsoil, and substratum).	ML or CL (surface soil, subsoil, and substratum).	Good to fair.	(1)	(1)	Fair to poor.	Good	Fair to poor.	Slopes erodible; moderate susceptibility to frost action.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—Continued							
Foundations	Dikes and levees	Low dams		Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
		Reservoir	Embankment				
[6]	[6]	[6]	[6]	[6]	[6]	Highly erodible; on steeper slopes may be impractical.	Highly erodible; maintenance costs may be excessive.
Good to poor bearing value; piping may be a hazard.	Erodible slopes.	[2]	[2]	Seasonally high water table; subject to occasional flooding; slow permeability.	High water-holding capacity; slow intake rate; adequate drainage is necessary.	[2]	Erodible; may be low in fertility.
[6]	[6]	[6]	[6]	[6]	[6]	[6]	[6].
Very poor to good bearing value; piping hazard.	Erodible slopes.	May have some seepage problem when excavated below 3 feet.	Poor to good stability on flat slopes; impervious.	High water table; subject to flooding; slow internal drainage.	Poor drainage makes irrigation impractical.	[2]	[2].
Good to poor bearing value; may have severe piping hazard.	May have serious piping problems; erodible slopes; may need slope protection.	[2]	[2]	Subject to frequent flooding; rapid permeability.	Frequent flooding makes irrigation impractical.	[2]	[2].
Poor to good bearing value; may be subject to piping.	Erodible slopes; piping may be a hazard.	Seepage may be a minor problem.	Poor to good stability; may require toe drains.	[2]	High water-holding capacity.	Field terraces generally not applicable; erodible.	Moderately erodible; high fertility makes vegetation potential good.

TABLE 7.—*Engineering*

Soil series and map symbols	Engineering classification		Suitability						Soil features affecting—
			As source of—			Of soil material for—			
	AASHO	Unified	Topsoil	Sand	Sand and gravel	Road subgrade		Road fill	Highway location
						Paved	Gravel		
Sarpy (Sg, Sl).	A–2 to A–6 (surface soil and subsoil); over A–2, A–3, or A–4 (substratum).	SM to ML (surface soil); over SM (subsoil); over SW or SP to SM (substratum).	Fair to poor.	Poor to fair.	Poor to fair.	Good to fair.	Good to poor.	Good to fair.	Low to high susceptibility to frost action; erodible slopes; water table may rise to near surface; 4 to 7 feet fill required.
Sharpsburg (Sh).	A–4 or A–6 (surface soil and subsoil); over A–6 or A–7–6 (substratum).	ML or CL (surface soil and subsoil); over CL or CH (substratum).	Good	(3)	(3)	Fair to poor.	Good	Fair to poor.	High to very high susceptibility to frost action; slopes may be erodible.
Sharpsburg and Marshall (SMA, SMB, SMB2, SMC, SMC2).	A–4 (surface soil); over A–4 to A–7–6 (subsoil and substratum).	ML or CL (surface soil); over ML to CH (subsoil); over CL or CH (substratum).	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Spoil banks (S).	(7)	(7)	(7)	(3)	(3)	(7)	(7)	(7)	(2)
Steinauer (StD2).	A–6 or A–7–6 (surface soil, subsoil, and substratum).	CL (surface soil, and subsoil); over CL or CH (substratum).	Poor to fair.	(3)	(3)	Poor	Good	Poor	Low to high susceptibility to frost action; slopes erodible.

[1] Sand or sand and gravel may occur at a depth below 8 feet.
[2] Because of position, topography, and slope, or any of these, this practice or structure is generally not needed or is not applicable.
[3] Sand or sand and gravel generally are not available.
[4] No apparent detrimental or especially favorable feature as related to construction or maintenance of this practice.

fill), may show a range, for example, good to fair. This range is the result of the variation of the soil in the profile.

In general, the soil features were rated according to the extent of the problems they might cause during the construction and maintenance of highways and agricultural structures and practices. The soil features shown for a given soil were based on the profile of that soil as shown in tables 5 and 6. Variations in this profile will change the ratings of the soil for use in some structures.

Frost action is a common engineering problem in the county because of the high content of silt and clay in many of the soils. The ratings for susceptibility to frost action shown in the column headed "Highway location" in table 7 have been estimated on the basis of the texture of the surface soil and subsoil. Clays and silts are susceptible to frost action if the underlying soil layers are pervious enough to permit water to rise and form the ice lenses.

Table 8 shows the criteria used for the frost-susceptibility ratings of the soils for which complete mechanical analyses were available.

Ratings for soils without mechanical analysis data were estimated by comparison with soils for which the mechanical analyses or other properties were known.

Foundation bearing values and piping hazards have been estimated for the part of the profile (as shown in table 6) below 3 feet.

interpretations—Continued

Soil features affecting—Continued							
Foundations	Dikes and levees	Low dams		Agricultural drainage	Irrigation	Field terraces and diversion terraces	Waterways
		Reservoir	Embankment				
Very good to poor bearing value; siltier sands may cause piping hazard.	Subject to piping; erodible slopes.	Seepage may be a problem where excavations are deeper than 3 feet.	Poor to good stability; foundation drains probably required.	Seasonally high water table; availability of drainage outlets may be a problem.	Low water-holding capacity; rapid intake rate; adequate drainage necessary.	Field terraces generally not applicable; diversion terraces erodible by wind and water without slope protection.	
Fair to poor bearing value; piping may be moderate hazard above 45 inches.	(2)	(4)	Fair to good stability; impervious.	(2)	High water-holding capacity; slow intake rate.	----------	
(6)	(6)	(6)	(6)	(6)	(6)	Erodible; on steeper slopes maintenance costs may be high.	Highly erodible on steeper or eroded slopes or on both; lacks fertility; maintenance costs may be excessive.
(7)	(2)	(2)	(2)	(2)	(2)	(2)	(2).
Good to poor bearing value.	(2)	(4)	Fair to good stability; impervious on flat slopes.	(2)	High water-holding capacity; slow intake rate; impractical because of steep slopes.	Highly erodible; on steeper slopes construction and maintenance costs may be excessive.	Highly erodible; construction and maintenance costs may be excessive.

[5] Interpretations are for both soils in the mapping unit, as these soils were not separated in mapping.

[6] Refer to the individual soils to obtain the ratings or soil features for the soils in this mapping unit.

[7] Because of the variable characteristics of this land type, this classification or engineering interpretation cannot be given.

Soil features affecting construction and maintenance of relatively low dikes and levees are shown in table 7. Therefore, the information given is for materials in approximately the upper 18 inches of the profile only. It is assumed that a detailed investigation of sites will need to be made for larger works of this kind.

Water is generally held satisfactorily without sealing protection in those reservoirs behind relatively small earth dams. Seepage losses are generally low.

Compacted embankments are generally impervious and have fair to good stability. Toe drains may be required. Workability of soil materials range from *good* for clays of low or medium plasticity to *poor* for clays of high plasticity.

Some of the bottom-land soils have poor natural drainage because of the seasonally high water table or slow permeability, or of both. Several of these soils are also subject to flooding. Others are quite flat, and runoff is slow. Soil permeability, topography, water table conditions, and available outlets determine the type of agricultural drainage that can be used effectively.

Under the column headed "Irrigation," soil features affecting available water (water-holding capacity and water-intake rate) have been rated. Irrigation hazards related to slope are not shown. "The Nebraska Irrigation Guide for Central and Eastern Nebraska," of the Soil Conservation Service (September 1959) contains informa-

TABLE 8.—*Criteria used to rate soils for susceptibility to frost action* [1]

Surface soil	Subsoil	Susceptibility rating
Percentage having grain size between 0.074 and 0.005 mm.—	*Percentage having grain size finer than 0.005 mm.*—	
64 or more	Less than 44	Very high.
64 or more	44 or more	High.
50 to 63	Less than 44	High.
50 to 63	44 or more	Moderate.
35 to 49	Less than 50	Moderate.
35 to 49	50 or more	Low.
Less than 35 percent (more than 3 percent finer than 0.02 mm.).	Subsoil not considered.	Low.
Less than 35 percent (3 percent or less finer than 0.02 mm.).	Subsoil not considered.	Not susceptible.

[1] Data from "Control of Soils in Military Construction" (*4*) were used in preparing this table.

tion on the suitability of various soils and slopes for irrigation and the use of soil amendments.

The rating for water-holding capacity, under the column headed "Irrigation," is based on the top 4 feet of the soil profile. The terms used indicate the amount of water held, as follows:

Water-holding capacity	*Rating*
More than 8 inches	High.
5 to 8 inches	Moderate.
3 to 5 inches	Low.
Less than 3 inches	Very low.

The intake rate, also shown in the column under "Irrigation," was indicated only if *slow* or *rapid*. A *slow* intake rate is less than ½ inch per hour; and a *rapid* intake rate is 2 inches or more per hour. If the intake rate was not classified, it fell between these two extremes. For all soils, the intake rate was based on border or sprinkler irrigation of areas with a plant cover.

Since a major part of the areas cropped is erodible, field terraces are commonly used in this county for soil and water conservation. Diversion terraces are used extensively below terraced or grassland fields to protect lower lying soils, as many of these soils, although highly erodible, are very productive. Although the slopes of terraces generally are erodible in this county, usually the cost of maintenance is not extremely high. The steeper slopes, however, may be exceptions. Hummocky topography may limit the use of field terraces and diversion terraces.

Waterways are also commonly used in the county. The hazards in both construction and maintenance of waterways are rated in table 7. The ratings are based upon construction in highly plastic soils and the hazard of erosion after construction, but before vegetation is established. The semihumid climate of the area helps to establish vegetation.

The soils of this county, in general, are not saline nor saline alkali, although some of the bottom-land soils are interspersed with very small alkali areas. Because of the small areas involved, saline or saline-alkali conditions, as they affect engineering practices, have not been rated for the soils in the county.

At many construction sites, major soil variations may occur within the depth of the proposed excavation. Several soil units may be encountered within a short distance. The soil maps and profile descriptions, as well as the engineering data in this section, should be used in planning detailed surveys of soils at construction sites. Use of the information in the soil survey reports will enable the soils engineer to concentrate on the most suitable soil units. Thus a minimum number of soil samples will be required for laboratory testing, and an adequate soil investigation can be made at minimum cost.

Genesis, Classification, and Morphology of Soils

The purpose of this section is to present the outstanding morphologic characteristics of the soils of Washington County and to relate them to the factors of soil formation. Physical and chemical data are limited for these soils, and the discussion of soil genesis and morphology is correspondingly incomplete. In the first part is discussed the environment of the soils; in the second, the classification of the soils; and in the third, the morphology of the soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed, and in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Generally, a long time is required for the development of distinct horizons.

The five factors of soil genesis are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The soils of the county have developed in three kinds of parent material—loess, alluvium, and glacial till. The soils developed in loess are the most extensive. They are the Belfore, Crofton, Monona, Marshall, Moody, Nora, and Sharpsburg soils. The major part of the loess is Peorian and is as much as 100 feet thick (*3*). The Peorian loess is calcareous silt loam to silty clay loam in texture and is grayish brown in color. A mantle of more recent, less calcareous loess is thought to cover the terraces and parts of the uplands (*7, 12*).

Alluvium is the second most extensive soil parent material and ranges from clay to sand in texture. The largest area of soils developed from alluvium is in the valley of the Missouri River. These soils are the Albaton, Carr, Haynie, Leshara, Luton, McPaul, Onawa, Rauville, Salix, Volin, and Sarpy. The Cass, Judson, and Kennebec soils are the most extensive Alluvial soils along the upland drains of Bell Creek and the Elkhorn River.

Silty material of the Loveland age occurs between the Peorian loess and Kansan till. Areas of the material exposed on the lower slopes are 5 to 10 feet in thickness and dark brown in color. As few of the exposed areas are large enough to be shown on the map, they are indicated by spot symbols.

Kansan till (*3*) is the parent material of Burchard and Steinauer soils. Little, if any, pre-Peorian weathering is evident in these soils. Kansan till is a calcareous clay loam that contains some glacial gravel and boulders.

Climate

Washington County has a mid-continental subhumid climate with moderate temperature. The soils in the county have probably developed under a climate similar to that of the present. Except for minor variations caused by slope or wind, the climate is uniform throughout the county. The steeper slopes and those facing south or west tend to be less leached because they are drier. The major differences in the soils of Washington County are caused by factors other than climate.

Plant and animal life

Postglacial vegetation in the area that is now Washington County was probably forest until about 6,000 years ago when grass began to take over (*11*). Since then, tall prairie grasses dominated the nearly level and rolling uplands. Deciduous trees covered the alluvial soils along the streams and the steep upland slopes adjacent to the bottom lands. Several centuries of root growth in the soil and the accumulation of vegetative remains on the surface have added considerable organic matter to the soil and have darkened the surface horizon. The soils developed under forest in this county apparently do not have any morphological features that set them apart. The upland soils developed under forest, however, usually have a thinner, darkened surface layer. Since many areas of these soils are on steeper slopes, the characteristics of this layer may not be due entirely to the type of vegetation.

All forms of plant and animal life contribute to soil formation. The addition of organic matter and the mixing that takes place in the soil depend on the kinds of plants and animals present and the environment, which includes soil climate.

The trees that once covered parts of the county have been cut for fuel or timber, and the land has been cleared for cultivation. Most of the land in prairie grass has been plowed and is now cultivated. As a result of the activities of man, most of the sloping fields have lost from one-third to two-thirds or more of the surface horizon. If allowed to continue, soil erosion would lower the productive capacity of the soils in the county.

Relief

Many soil differences in the county are caused by relief. Relief affects drainage, runoff, erosion, and deposition. Slopes differ in gradient, length, shape, and exposure. Some or all of these slope characteristics are responsible for the differences between soils derived from similar parent material, such as Burchard and Steinauer, Marshall and Crofton, and Belfore and Moody. Steep slopes cause rapid runoff; the result of runoff is that little water penetrates the soil and thin soils develop.

On bottom lands the lack of relief and the need for drainage cause differences in soils. The differences between Salix and Leshara, Cass and Carr, and Onawa and Rauville are examples.

Time

The length of time soil materials have been exposed to soil-forming processes is important.

The younger soils of the county have not had time to develop differentiating soil horizons. Soils on steep slopes constantly lose soil material, and new material is exposed to weathering. Most of those on the bottom lands receive additional deposits of alluvial sediments, either through flooding or through slope wash.

The loessal materials of the nearly level to sloping uplands have been in place since the last glaciation, which was between 8,000 and 10,000 years ago. The Belfore and Sharpsburg soils that developed from Peorian loess show genetically related horizons in their profile.

The till from which the Burchard and Steinauer soils have been formed was deposited during the Kansas glacial stage. After the retreat of the glacier, the till was weathered and leached and in all probability soils were formed over the land surface. Subsequently, however, the land surface was dissected by erosion and the soils and much of the leached till were removed. The land surface was then mantled generally by Peorian loess and part of it was later removed from the more sloping areas to reexpose slightly weathered till. The Burchard and Steinauer soils formed from this till are thus the same age or are younger than the soils formed from loess.

Classification of Soils by Higher Categories

Soils are placed in narrow classes for the organization and application of knowledge about their behavior within farms, ranches, or counties. They are placed in broad classes for study and comparisons of large areas such as continents. In the comprehensive system of soil classification followed in the United States (*2*), the soils are placed in six categories, one above the other. Beginning at the top, the six categories are order, suborder, great soil group, family, series, and type.

In the highest category, the soils of the whole country are grouped into three orders, whereas thousands of soil types are recognized in the lowest category. The suborder and family categories have never been fully developed and thus have been little used. Attention has been given largely to the classification of soils into soil types and series within counties or comparable areas and to the subsequent grouping of series into great soil groups and orders. Soil series, type, and phase are defined in "How Soils are Named, Mapped, and Classified" and in the Glossary.

Subdivisions of soil types into phases provide finer distinctions significant to soil use and management.

The highest category in the present system of soil classification consists of three soil orders, the zonal, intrazonal, and azonal (*13*). The zonal order comprises soils with evident, genetically related horizons that reflect the dominant influence of climate and living organisms in their formation. In the intrazonal order are soils with evident, genetically related horizons that reflect the dominant influence of local factors of parent material, topography, and time over the effects of climate and living organisms. In the azonal order are soils that lack distinct, genetically related horizons because of one or more of the following—youth of parent materials, resistance of parent materials to change, and steep topography.

In table 9 the soil series are classified by higher categories, and their important characteristics are given. Following the table is a discussion of the morphology of the soil series and a description of a typical soil profile for each series. The soils are discussed according to order and great soil group.

Great soil groups in Washington County

A great soil group consists of many soil types that have profiles with major features in common. Every soil type in any one great soil group has the same number and kinds of definitive horizons, although they need not be expressed in every profile to the same degree. Collectively, the members of a single great soil group have a wide range in many characteristics or properties. They may also have a wide range in fertility, tilth, moisture-holding capacity, susceptibility to erosion, and other qualities.

The great soil groups in Washington County are the Brunizems, Chernozems, Humic Gley soils, Regosols, and Alluvial soils.

BRUNIZEMS

The Brunizems are a zonal group of soils with a very dark grayish-brown, fairly thick A1 horizon when not eroded. Horizon boundaries are gradual rather than abrupt. Brunizems do not have A2 horizons but have B horizons that can be distinguished from the A and C horizons by texture, color, or structure. These soils have developed in areas of tall grasses where the climate is humid and temperate. Carbonates are generally leached from the solum of these soils.

In Washington County the soils classified as Brunizems are the Burchard, Marshall, Monona, and Sharpsburg series. The Judson, Kennebec, Salix, and Volin are Alluvial soils that intergrade to this group and have a weakly developed B horizon.

CHERNOZEMS

The Chernozems are a zonal group of soils having a thick, dark, usually granular surface horizon that is well supplied with organic matter. The subsoil is lighter colored and in many places is finer textured than the surface horizon and has stronger structure. In many places calcium carbonate has accumulated in the lower subsoil of the silty or clayey soils of this group, but the lime may be leached to a greater depth in sandy soils. As Washington County is at the eastern edge of the Chernozem soil zone, the difference between the Chernozems and Brunizems in the county is small. The soil series in the Chernozem great soil group are the Belfore, Moody, and Nora.

TABLE 9.—*Soil series classified according to soil orders and great soil groups and some characteristics that affect morphology*

Great soil group and series	Parent material	Relief	Draina e
ZONAL			
Brunizems:			
Burchard	Kansan till	Rolling to steep.	Well drained.
Marshall	Peorian loess	Nearly level to rolling.	Well drained.
Monona	Peorian loess	Nearly level to steep.	Well drained.
Sharpsburg	Peorian loess	Nearly level to rolling.	Well drained.
Chernozems:			
Belfore	Peorian loess	Nearly level	Well drained.
Moody	Peorian loess	Gently sloping to rolling.	Well drained.
Nora	Peorian loess	Rolling to moderately steep.	Well drained.
INTRAZONAL			
Humic Gley soils:			
Colo	Clayey alluvium.	Nearly level	Imperfectly drained.
Lamoure	Clayey alluvium.	Nearly level	Imperfectly drained.
Luton	Clayey alluvium.	Nearly level	Somewhat poorly drained.
Rauville	Silty to clayey alluvium.	Nearly level	Poorly drained.
AZONAL			
Regosols:			
Crofton	Peorian loess	Rolling to steep.	Excessively drained.
Steinauer	Kansan till	Rolling to steep.	Excessively drained.
Alluvial soils:			
Albaton	Clayey alluvium.	Nearly level	Somewhat poorly drained.
Carr	Sandy alluvium.	Nearly level	Imperfectly drained.
Cass	Sandy alluvium.	Nearly level	Well drained.
Haynie	Silty alluvium	Nearly level	Imperfectly drained.
Judson	Silty alluvium	Nearly level to gently sloping.	Well drained to moderately well drained.
Kennebec	Silty alluvium	Nearly level	Well drained.
Leshara	Silty alluvium	Nearly level	Imperfectly drained.
McPaul	Silty alluvium	Nearly level	Moderately well drained.
Onawa	Clayey alluvium.	Nearly level	Somewhat poorly drained.
Salix	Silty alluvium	Nearly level	Well drained.
Sarpy	Sandy alluvium.	Nearly level to hummocky.	Well drained.
Volin	Silty alluvium	Nearly level	Well drained.

HUMIC GLEY SOILS

The Humic Gley soils are in the intrazonal order. They occur in this county on the bottom lands. They have a thick, dark surface horizon that is high in content of organic matter. The subsoil is gleyed where the dark organic staining does not mask the color. In many places the subsoil or substratum is calcareous. Humic Gley soils have developed under tall grass and sedge vegetation and are somewhat poorly drained to poorly drained. The Humic Gley soils in this county are the Luton, Rauville, Lamoure and Colo. The last two soils might be considered as intergrading to Alluvial soils.

REGOSOLS

Regosols are azonal soils. The soils in this great soil group in the county are the Crofton and Steinauer. They are only moderately dark, and as they occur on the steeper slopes, they have thin, weakly developed horizons.

ALLUVIAL SOILS

The Alluvial soils are azonal soils that developed in recently deposited alluvium. These soils have been weakly modified by soil-forming processes. The addition of organic matter has darkened the surface horizon and is about the only evidence of soil formation. Textured stratification is the most evident profile characteristic. In Washington County the Albaton, Carr, Cass, Haynie, Judson, Kennebec, Leshara, McPaul, Onawa, Salix, Sarpy, and Volin soils are in this great soil group.

Morphology

This section was prepared for those who need more scientific information about the soils in the county than is given elsewhere in the report. In the following pages, each soil series is described, and a detailed profile description of a soil representative of the series is given. The profile descriptions were prepared after studying profiles at specific sites in the county.

The topography, surface drainage, permeability, vegetation, range in characteristics, and dominant land use of the soils are given in the section "Descriptions of the Soils."

Albaton series

The Albatons are moderately dark, imperfectly drained Alluvial soils in the Brunizem soil zone. These soils are deep, have a fine-textured subsoil, and are more than 3 feet thick over stratified sand and silt. The depth of the water table fluctuates; it is from 2 to 5 feet below the surface. The surface has been occasionally flooded. The Albaton soils are on the low bottom lands of the Missouri River flood plain and in some places consist of recently deposited, fine-textured sediment.

Profile of Albaton clay in a cultivated field (0.25 mile east of the northwest corner of sec. 13, T. 18 N., R. 12 E.):

A1p—0 to 4 inches, light olive-gray (5Y 6/2) clay, olive gray (5Y 5/2) when moist; weak, medium, platy structure; hard when dry, firm when moist; calcareous; abrupt, smooth boundary.

A12—4 to 12 inches, olive-gray (5Y 5/2) clay, dark olive gray (5Y 3/2) when moist; weak, fine, granular structure; hard when dry, firm when moist; calcareous; clear, smooth boundary.

AC—12 to 30 inches, pale-olive (5Y 6/3) clay, olive gray (5Y 5/2) when moist; moderate, medium and fine, granular structure; very hard when dry, very firm when moist; calcareous; gradual, smooth boundary.

C—30 to 40 inches, olive-gray (5Y 5/2) clay, olive gray (5Y 5/2) when moist; streaked and mottled with light gray (5Y 7/2), light olive gray (5Y 6/2) when moist; massive (structureless); very hard when dry, very firm when moist; calcareous; a few, fine, distinct iron stains; abrupt, wavy boundary.

D—40 to 50 inches, light-gray (10YR 7/2) stratified fine sand and silt, light brownish gray (10YR 6/2) when moist.

Albaton soils vary extremely, both in texture of the surface horizon and in profile stratification. Areas mapped in this series, however, have a fine-textured subsoil but have significant inclusions of coarser textured soils.

Belfore series

The soils of the Belfore series are moderately fine textured to fine textured Chernozems of the loessal uplands. They are deep, well-drained soils that occur on the nearly level ridgetops west of Bell Creek. They have a dark silty clay loam surface horizon and a heavy silty clay loam subsoil that grades into the parent loess of silty clay loam to silt loam.

Profile of Belfore silty clay loam in a field of wheat (400 feet west and 100 feet south of the northeast corner of NW¼ sec. 3, T. 18 N., R. 9 E.; at this location the soil was included in an area mapped with Moody silty clay loam; analytical data for this Belfore profile in table 10):

A1p—0 to 6 inches, dark grayish-brown (10YR 4/1.5, dry) silty clay loam, dark brown (10YR 2/1.5) when moist; weak, subangular blocky clods that break to moderate, fine and very fine granules; slightly hard when dry, friable when moist; no effervescence; abrupt, smooth boundary.

A12—6 to 9 inches, very dark grayish-brown (10YR 3.5/2, dry) silty clay loam; crushes to 10YR 4/3 when moist; dark brown (10YR 2/1.5) when moist; moderate, medium, subangular blocky and weak, medium, platy structure in compacted plow layer; hard when dry, friable when moist; numerous worm casts; abundant roots; no effervescence; clear, smooth boundary.

B1—9 to 14 inches, dark grayish-brown (10YR 4/2.5, dry) silty clay loam; crushes to 10YR 3.5/3 when moist; very dark grayish brown (10YR 3/2.5) when moist; moderate, fine, subangular blocky structure that breaks to fine, granular; hard when dry, friable when moist; abundant roots; numerous fine pores; few worm casts; no effervescence; clear, smooth boundary.

B21—14 to 20 inches, dark-brown (10YR 4.5/3, dry) silty clay loam; crushes to 10YR 4/3 when moist; dark brown (10YR 3/3) when moist; weak, medium, prismatic structure that breaks to moderate, medium and fine, subangular blocky; slightly firm when moist, hard when dry; thin, continuous coatings on aggregates; numerous, medium and fine pores; few worm casts; abundant roots; no effervescence; clear, smooth boundary.

B22—20 to 30 inches, brown (10YR 5/3, dry) silty clay loam; crushes to 10YR 4/3 when moist; dark brown (10YR 3.5/3) when moist; moderate, medium and coarse, prismatic structure that breaks to moderate, medium and fine, subangular blocky; slightly firm when moist, hard when dry; thin, continuous coatings on aggregates; numerous, medium and fine pores; few worm casts; abundant roots; no effervescence; clear, smooth boundary.

B23—30 to 42 inches, brown (10YR 5/3, dry) silty clay loam; crushes to 10YR 4/3, when moist; dark grayish brown (10YR 4/2.5) when moist; moderate, coarse, prismatic structure that breaks to weak, medium, subangular blocky; slightly firm when moist, hard when dry; thin coatings on large aggregates; patchy, thin coatings on smaller aggregates; common, distinct, fine mottles of yellowish brown; abundant roots on faces of larger aggregates; no effervescence, clear, smooth boundary.

C—42 to 60 inches, brown (10YR 5/3, dry) silty clay loam, grayish brown (10YR 4/2.5) when moist; weak, coarse, prismatic structure; friable when moist, slightly hard when dry; common, faint, fine, yellowish-brown mottles; common, distinct, fine, gray mottles; distinct, fine, few, very dark brown, soft concretions of iron and manganese; no effervescence.

The thickness of the surface horizon varies as much as 8 inches between the low ridges and swales. The texture of the subsoil may range from a medium silty clay loam to a light silty clay. The Belfore soils in the counties to the west and north have more clay and stronger structure in the B horizon than does the profile described. Otherwise, the Belfore are relatively uniform soils.

Burchard series

The soils of the Burchard series are Brunizems that developed on the calcareous till in the rolling to steeply rolling uplands. The surface horizon is dark, moderately fine textured, and moderately thick. The subsoil is browner and somewhat finer textured than the surface horizon and has subangular blocky structure. The surface horizon and upper subsoil are noncalcareous, but the lower subsoil and substratum are calcareous. The Burchard soils are scattered throughout the uplands where glacial till outcrops along the larger streams. There are areas of significant size only in the bluff zone of the Missouri River, however.

Profile of Burchard clay loam in a cultivated field (north of the center of sec. 32, T. 19 N., R. 11 E.):

A1p—0 to 7 inches, dark-gray (10YR 4/1, dry) clay loams, very dark grayish brown (10YR 3/2) when moist; weak, fine and very fine, granular structure; hard when dry, friable when moist; noncalcareous; abrupt, smooth boundary.

A12—7 to 10 inches, dark-gray (10YR 4/1, dry) clay loam, very dark brown (10YR 2/2) when moist; weak, fine and very fine, granular structure; hard when dry, very friable when moist; noncalcareous; clear, wavy boundary.

B1—10 to 14 inches, dark grayish-brown (10YR 4/2, dry) clay loam, dark brown (10YR 3/3) when moist; moderate, fine and medium, granular structure; hard when dry, friable when moist; noncalcareous; clear, wavy boundary.

B21—14 to 18 inches, dark grayish-brown (10YR 4/2, dry) clay loam, very dark grayish brown (10YR 3.5/2) when moist; weak, coarse, prismatic structure that breaks to moderate, fine and very fine granular; hard when dry, friable when moist; noncalcareous; clear, wavy boundary.

B22—18 to 26 inches, brown (10YR 5/3, dry) clay loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, prismatic structure that breaks to weak, fine, subangular blocky; hard when dry, friable when moist; noncalcareous; clear, wavy boundary.

B3ca—26 to 34 inches, light brownish-gray (10YR 6/2, dry) clay loam, brown (10YR 5/3) when moist; weak, medium and coarse, subangular blocky structure that breaks to moderate, fine, granular; hard when dry, friable when moist; violent effervescence; common, faint, yellowish-brown and gray mottlings; numerous lime concretions; clear, wavy boundary.

C—34 to 60 inches, light brownish-gray (2.5Y 6/2, dry) clay loam to light clay, grayish brown (2.5Y 5/2) when moist; massive (structureless); hard when dry, firm when moist; violent effervescence; many, coarse, prominent yellowish-brown to brown mottles and few dark-brown to black mottles; iron and manganese concretions are present.

The surface horizon varies in thickness and texture with the slope and amount of erosion. Loss of soil from the surface horizon has reduced the content of organic matter and has changed the texture from a friable light clay loam to a firm heavy clay loam.

Carr series

The Carr series consists of deep, moderately coarse, imperfectly drained Alluvial soils of the low bottom lands along the Missouri River. In the past they have been flooded almost annually, and the surface horizon is made up of recently deposited, calcareous sandy material. In many places this material is over medium- to coarse-textured buried soils.

Profile of Carr fine sandy loam in a cultivated field (0.2 mile south and 0.2 mile east of the northwest corner of sec. 17, T. 18 N., R. 12 E.):

A1p—0 to 7 inches, pale-brown (10YR 6/3, dry) fine sandy loam, grayish brown (10YR 5/2) when moist; weak, very fine, crumb structure; soft when dry, very friable when moist; moderately calcareous; abrupt, smooth boundary.

AC—7 to 22 inches, grayish-brown (2.5Y 5/2, dry) fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, crumb structure; soft when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C1—22 to 28 inches, grayish-brown (2.5Y 5/2, dry) fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; massive (structureless); soft when dry, very friable when moist; strongly calcareous; clear, wavy boundary.

C2—28 to 44 inches, dark grayish-brown (2.5Y 4/2, dry) very fine sandy loam, very dark grayish brown (2.5Y 3/2) when moist; massive (structureless); strongly calcareous; clear wavy boundary. (This horizon may be the surface horizon of a former soil.)

C3—44 to 50 inches, grayish-brown (2.5Y 5/2, dry) very fine sandy loam, dark grayish brown (2.5Y 4/2) when moist; stratified with fine sandy loam; massive (structureless); strongly calcareous; these soils are usually not mottled.

The texture of the surface horizon is quite variable, and the profile is stratified in many places because of recent deposition. Small areas of finer textured Albaton and Onawa soils in old channels, or of Sarpy soils on ridges, are included with the Carr soils.

Cass series

The Cass series consists of dark, immature Alluvial soils on the well-drained part of the Elkhorn River bottom lands. They formed in nearly level, recent sandy deposits that are usually underlain at a depth between 3 and 10 feet by sand or mixed sand and gravel. There is little or no lime in the profile. Mottles may be present in the lower part of the subsoil.

Profile of Cass loam in a cornfield (800 feet north and 330 feet east of the southwest corner of sec. 8, T. 18 N., R. 9 E.):

A1p—0 to 7 inches, dark-gray (10YR 4/1, dry) loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt, smooth boundary.

A12—7 to 14 inches, very dark grayish-brown (10YR 3/2, dry) loam, very dark brown (10YR 2/2) when moist;

weak, fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; clear wavy boundary.

C1—14 to 42 inches, grayish-brown (10YR 5/2, dry) fine sandy loam, dark gray (10YR 4/1) when moist; weak, coarse, prismatic structure that breaks to weak, coarse, granular; soft when dry, very friable when moist; a few fine, faint, reddish-brown mottles; noncalcareous; abrupt, smooth boundary.

C2—42 to 50 inches, light-gray (10YR 6/1, dry) fine sand, grayish brown (10YR 5/2) when moist; single grain; loose when dry and moist; noncalcareous; clear, wavy boundary.

C3—50 to 60 inches +, light brownish-gray (10YR 6/2, dry) sand, grayish brown (10YR 5/2) when dry; single grain.

The principal variations in the Cass soils are in the thickness of the dark surface horizon and in the color and thickness of the layer transitional to the substratum.

Colo series

The Colo series consists of imperfectly drained soils that formed in moderately fine textured material along the larger drains in the uplands. These are Humic Gley soils and are largely in the Brunizem soil zone. They have developed in material washed from the loessal uplands. They are generally noncalcareous, but a few large, irregular lime concretions may be present in the lower part of the profile.

Profile of Colo silty clay loam in a cultivated field (0.35 mile north and 300 feet east of the southwest corner of sec. 19, T. 18 N., R. 10 E.):

A1p—0 to 6 inches, dark-gray (10YR 4/1, dry) silty clay loam, black (10YR 2/1) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

A11—6 to 14 inches, dark-gray (10YR 4/1, dry) silty clay loam, black (10YR 2/1) when moist; moderate, fine, granular structure; friable when moist, slightly hard when dry; noncalcareous; clear, smooth boundary.

A12—14 to 24 inches, dark-gray (10YR 4/1, dry) silty clay loam, black (10YR 2/1) when moist; strong, fine, granular structure; hard when dry, firm when moist; noncalcareous; clear, wavy boundary.

AC—24 to 36 inches, dark-gray (10YR 4/1, dry) silty clay loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; very firm when moist, hard when dry; noncalcareous; gradual, wavy boundary.

C—36 to 50 inches, gray (10YR 5/1, dry) silty clay, very dark gray (10YR 3/1) when moist; massive (structureless); very firm when moist, very hard when dry; noncalcareous; few, fine, faint yellowish-brown mottlings.

The surface soil ranges from 20 to 30 inches in thickness. The depth to underlying silty clay or clay horizon ranges from 30 to 50 inches. The substratum has considerable variation in color, depth, and texture, as well as in amount of lime.

Crofton series

Crofton soils are deep and silty Regosols that have a thin, moderately dark surface horizon and little profile development. They occur in the uplands on rolling to steep slopes, primarily in the Missouri River bluff zone and also on the slopes that slant into the Elkhorn River bottom lands. They are excessively drained and may have lime near the surface.

The Crofton soils are associated with Monona and Steinauer soils in the bluff zones and with Nora and Moody soils in the rest of the county. They have a thinner, lighter colored surface horizon than the Monona soils and have lime higher in the profile. They are coarser textured than the Steinauer and Burchard soils, which developed in clay loam till. Crofton soils have a thinner, lighter colored surface horizon and less profile development than the Nora and Moody soils, and they occur on steeper slopes. Crofton soils are similar to the Ida soils of western Iowa.

Profile of Crofton silt loam, 18 to 30 percent slopes, in native pasture (0.35 mile north and 25 feet east of the center of sec. 31, T. 18 N., R. 12 E.):

A1—0 to 6 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist, soft when dry; noncalcareous; abrupt, smooth boundary.

AC—6 to 12 inches, brown (10YR 5/3, dry) silt loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; very friable when moist, soft when dry; noncalcareous; clear, smooth boundary.

C1—12 to 26 inches, light yellowish-brown (10YR 6/4, dry) silt loam, yellowish brown (10YR 5/4) when moist; weak, coarse, prismatic structure that breaks to moderate, fine and medium, granular structure; very friable when moist; soft when dry; strong effervescence; clear, wavy boundary.

C2—26 to 60 inches, light yellowish-brown (2.5Y 6/4, dry) silt loam, light olive brown (2.5Y 5/4) when moist; weak, coarse, prismatic structure that breaks to massive; very friable when moist, soft when dry; violent effervescence.

There is considerable variation in the Crofton soils in depth to lime and the amount of lime. Some of the most recent loess is only slightly calcareous. The surface horizon varies greatly in thickness and color, depending on the erosion that has taken place.

Haynie series

The Haynie series consists of nearly level, imperfectly drained, moderately dark colored Alluvial soils. These soils have formed in sediments recently deposited by the Missouri River. The floods of recent years have deposited material on most areas of these soils. In many places the Haynie soils are stratified with moderately fine textured and moderately sandy materials. They are usually calcareous throughout the profile.

Profile of Haynie silt loam in a cultivated field near the riverbank (0.5 mile east and 0.25 mile north of the southwest corner of sec. 17, T. 18 N., R. 12 E.):

A1p—0 to 8 inches, light brownish-gray (10YR 6/2, dry) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular structure; strongly calcareous; very friable when moist; abrupt, smooth boundary.

AC—8 to 22 inches, light brownish-gray (10YR 6/2, dry) silt loam, dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure; very friable when moist; strongly calcareous; clear, wavy boundary.

C1—22 to 40 inches, light brownish-gray (10YR 6/2, dry) very fine sandy loam, grayish brown (10YR 5/2) when moist; massive (structureless); very friable when moist; slightly calcareous; clear, wavy boundary.

C2—40 to 50 inches, light brownish-gray (10YR 6/2, dry) very fine sandy loam, brown (10YR 5/3) when moist; weak, very fine, granular structure; very friable when moist; strongly calcareous.

Variations in the thickness and texture of the surface horizon are common. Although on the average the subsoil is medium textured, it contains strata of sandy loam in numerous places.

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Judson series

The Judson series consists of immature soils that developed from colluvial-alluvial material. These are Alluvial soils in the Brunizem soil zone. They have deep, dark-colored, noncalcareous, silty profiles. They have developed on nearly level to gentle slopes in the silty material that washed downslope, usually from loessal uplands.

Profile of Judson silt loam in a cultivated field (500 feet north and 1,100 feet west of the southeast corner of sec. 14, T. 19 N., R. 10 E.):

A1p—0 to 8 inches, dark-gray (10YR 4/1, dry) silt loam, black (10YR 2/1) when moist; weak, fine, granular structure; very friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

A1—8 to 20 inches, dark-gray (10YR 4/1, dry) silt loam, black (10YR 2/1) when moist; moderate, fine, granular structure; very friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

AC—20 to 28 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, coarse, subangular blocky structure that breaks to moderate, fine and medium, granular; slightly friable when moist, slightly hard when dry; noncalcareous; gradual, smooth boundary.

C1—28 to 44 inches, grayish-brown (10YR 5/2, dry), light silty clay loam, dark grayish brown (10YR 4/2) when moist; weak, coarse, subangular blocky structure that breaks to weak, fine, granular; very friable when moist, slightly hard when dry; noncalcareous; materials from horizon above mixed throughout this horizon; gradual, smooth boundary.

C2—44 to 60 inches, light brownish-gray (10YR 6/2, dry) silty clay loam, dark brown (10YR 4/3) when moist; massive (structureless); very friable when moist, slightly hard when dry; noncalcareous; many fine, distinct reddish-brown and gray mottles.

The principal variations in these soils are in the thickness of the surface horizon.

Kennebec series

The Kennebec series consists of well-drained Alluvial soils. These are young soils that have developed through slow accumulation of dark silty material along the upland drains. The Kennebec soils show little horizonation, are stratified in many places, and are usually noncalcareous.

Profile of Kennebec silt loam in a cultivated field (0.25 mile east and 75 feet south of the northwest corner of sec. 13, T. 19 N., R. 10 E.):

A1p—0 to 6 inches, very dark grayish-brown (10YR 3/2, dry) silt loam, very dark brown (10YR 2/2) when moist; weak, fine, granular structure; very friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

A1—6 to 15 inches, very dark gray (10YR 3/1, dry) silt loam, very dark brown (10YR 2/2) when moist; weak, coarse, subangular blocky structure that breaks to moderate, fine and medium, granular; slightly hard when dry, very friable when moist; noncalcareous; clear, smooth boundary.

AC—15 to 30 inches, dark grayish-brown (10YR 4/2, dry) silt loam, dark brown (10YR 3/3) when moist; weak, coarse, subangular blocky structure that breaks to moderate, fine and medium, granular; very friable when moist, slightly hard when dry; noncalcareous; clear, smooth boundary.

C1—30 to 48 inches, grayish-brown (10YR 5/2, dry) silt loam, dark brown (10YR 4/3) when moist; weak, fine, granular structure; very friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

C2—48 to 60 inches +, light brownish-gray (10YR 6/2, dry) silt loam, dark brown (10YR 4/3) when moist; massive (structureless); very friable when moist, slightly hard when dry; gray and yellowish-brown mottles; noncalcareous.

These soils vary mainly in having stratification and overflow deposits in some areas. Some of the high-lying areas show evidence of profile development. In some places, fine-textured strata are in the lower part of the profile.

Lamoure series

The Lamoure series consists of imperfectly drained, nearly level soils that developed in alluvial material. These are considered Humic Gley soils, but in many places the high content of organic matter masks any gleying that is present. The Lamoure soils are generally calcareous below the A horizon, and in places they are calcareous to the surface.

Profile of Lamoure silty clay loam in a cultivated field (0.1 mile east and 50 feet south of the northwest corner of sec. 14, T. 18 N., R. 9 E.):

A1p—0 to 8 inches, very dark gray (10YR 3/1, dry) silty clay loam, black (10YR 2/1) when moist; moderate, fine, granular structure; friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

A12—8 to 16 inches, very dark gray (10YR 3/1, dry) silty clay loam, black (10YR 2/1) when moist; weak, coarse, subangular blocky structure that breaks to moderate, fine, granular; friable when moist, slightly hard when dry; clear, smooth boundary.

AC—16 to 35 inches, dark-gray (10YR 4/1, dry), heavy silty clay loam, black (10YR 2/1) when moist; strong, fine, subangular blocky structure; firm when moist, hard when dry; strongly calcareous; abrupt, smooth boundary.

C—35 to 60 inches +, dark-gray (10YR 4/1, dry) silty clay, very dark gray (10YR 3/1) when moist; massive (structureless); many fine, distinct gray mottles; firm when moist, hard when dry; strongly calcareous.

These soils vary in thickness of horizon, in color, and in depth to lime.

The Lamoure soils are not shown as separate mapping units on the detailed soil map. Areas of the Lamoure soils were so intimately associated with areas of the Colo soils that the two kinds of soil were mapped together as a complex.

Leshara series

The Leshara series consists of imperfectly drained, medium-textured Alluvial soils. They occur on the nearly level bottom lands along the Elkhorn and Missouri Rivers. The Leshara soils are noncalcareous, but in some areas may have a small amount of lime in the lower profile.

Profile of Leshara silt loam in a cultivated field (0.25 mile west of the center of sec. 13, T. 17 N., R. 9 W.):

A1p—0 to 10 inches, dark-gray (10YR 4/1, dry) silt loam, black (10YR 2/1) when moist; weak, fine and medium, granular structure; very friable when moist, soft when dry; noncalcareous; abrupt, smooth boundary.

A12—10 to 24 inches, grayish-brown (10YR 5/2, dry) very fine sandy loam, very dark gray (10YR 3/1) when moist; moderate, fine, granular structure; soft when dry, very friable when moist; noncalcareous; clear, wavy boundary.

C1—24 to 46 inches, grayish-brown (10YR 5/2, dry) very fine sandy loam, dark grayish brown (10YR 4/2) when moist; massive (structureless); very friable when moist, soft when dry; noncalcareous; few, fine, faint reddish-brown mottles; clear, wavy boundary.

C2—46 to 60 inches, light brownish-gray (10YR 6/2, dry) horizon that is stratified with very fine sandy loam, silt loam, and fine sand; light gray (10YR 4/1) when moist; massive (structureless); very friable when moist, soft when dry; slightly calcareous; few, fine, faint, reddish-brown mottles.

The Leshara soils have a medium-textured subsoil. Areas mapped as a complex with Luton clay have a clay surface horizon. Where adjacent to areas of Luton clay, the Leshara soils have a clay substratum.

Luton series

The Luton series consists of fine-textured soils that developed in clayey alluvium on the high bottom lands along the Missouri River and Bell Creek. These are Humic Gley soils. They may be flooded occasionally, and, because of nearly level slopes and slow permeability, they drain slowly. These soils are mostly alkaline, but in numerous places they are calcareous, especially in the substratum.

Profile of Luton clay in a cultivated field of wheat (300 feet east and 100 feet south of the northwest corner of sec. 10, T. 19 N., R. 11 E.; analytical data for this Luton profile in table 10):

A1p—0 to 5 inches, dark-gray (2.5Y 4/1, dry) clay, very dark gray (2.5Y 3/1) when moist; strong, medium and fine, granular structure; firm when moist, hard when dry; weak effervescence; abrupt, smooth boundary.

A12—5 to 9 inches, dark-gray (2.5Y 4/1, dry) clay, very dark grayish brown (2.5Y 3/2) when moist; strong, medium and fine, granular structure; firm when moist, hard when dry; weak effervescence; a few, small fragments of snail shells throughout and a few, fine flecks of segregated lime in lower inch; abrupt, smooth boundary.

A1b—9 to 12 inches, very dark gray (2.5Y 3/1, dry) clay, very dark gray (2.5Y 3/1) when moist; moderate, medium and fine, blocky structure that breaks to strong, fine granular; firm when moist, very hard when dry; noncalcareous matrix with an occasional fleck of segregated lime; clear, smooth boundary.

Cb—12 to 16 inches, very dark gray (2.5Y 3/0, dry) clay, very dark grayish brown (2.5Y 3/2) when moist; moderate, medium, blocky structure that breaks to fine and very fine angular blocks; weak to strong effervescence; numerous, fine, white spots of segregated calcium carbonate; few, calcareous shell fragments; common, medium, distinct, yellowish-brown mottles; abrupt, smooth boundary.

A1b2—16 to 26 inches, dark-gray (2.5Y 4/0, dry) clay, black (2.5Y 2/1) when moist; strong, medium and fine, angular blocky structure; very firm when moist, very hard when dry; common, fine, distinct, yellowish-brown and reddish-brown mottles; lower part of horizon somewhat mixed with horizon below; no effervescence; an occasional iron-manganese pellet, 1/8 to 1/4 inch in diameter; clear, smooth boundary.

Cb2—26 to 38 inches, dark-gray (2.5Y 4/0, dry) clay, very dark grayish brown (2.5Y 3/2) when moist; moderate, coarse, prismatic structure that breaks to strong, medium, blocky; very firm when moist, very hard when dry; common, medium and coarse, distinct, yellowish-brown mottles; no effervescence except on an occasional firm spot of segregated lime in lower 2 inches of this horizon; clear, smooth boundary.

A1b3—38 to 46 inches, very dark gray (2.5Y 3/0, dry) clay, black (2.5Y 2/1) when moist; moderate, medium, prismatic structure that breaks to strong, medium and fine, blocky; very firm when moist, very hard when dry; in moist areas aggregates have shiny coats; matrix noncalcareous; few, fine and medium, hard concretions of lime; some faint, yellowish-brown mottling but most mottling marked by dark color; abrupt, wavy boundary.

Cgca—46 to 60 inches, consists of several thin horizons of dark (2.5Y 2/1, moist) moist clay and very dark grayish brown (2.5Y 3/2) moist clay; these horizons are caused by periods of thin deposition and intervals of soil development; strong, medium and fine, blocky structure; very firm when moist, plastic when wet; strong effervescence; numerous, fine to coarse spots of segregated lime; few, distinct, fine and medium, yellowish-brown mottles; entire horizon appears to be gleyed; free water at a depth of about 68 inches.

The surface horizon of some of the Luton soils in this county, as well as elsewhere in Nebraska, is thicker and darker than that of the profile described. It varies in thickness and color with small changes in drainage. Also buried soils in some of the Luton soils are less prominent than described. The depth to lime and the form of the lime in the soil depends on the length of time the soil has been in place.

Marshall series

The soils of the Marshall series are deep, medium to moderately fine textured Brunizems. They occur in the gently sloping to rolling parts of the loessal uplands between Bell Creek and the Missouri River bluff zone. They have a dark surface horizon and a brown, moderately fine textured subsoil. Their solum is normally lime free, but some lime is present in places in the loessal substratum. The Marshall soils have adequate surface and internal drainage.

Profile of Marshall silty clay loam in a field of oats and sweetclover (450 feet west and 110 feet north of southeast corner of SW1/4 sec. 29, T. 17 N., R. 11 E.; analytical data for this Marshall profile in table 10):

A1p—0 to 7 inches, dark-brown (10YR 3/3, dry) silty clay loam, very dark brown (10YR 2/2) when moist; weak, fine to very fine, granular structure; hard when dry and very friable when moist; some worm casts and channeling; fragments of lime that was added to this field 1 year ago can be seen; effervescence only on these fragments; clear, smooth lower boundary.

B21—7 to 15 inches, brown (10YR 4/3, dry) silty clay loam, dark brown (10YR 3/3) when moist; moderate, coarse, prismatic structure that breaks to moderate, fine and very fine, blocky; faces of blocky peds are shiny brown but when crushed are yellowish brown (10YR 5/4) when dry; some worm casts and channeling; roots thick in this horizon; clear, wavy lower boundary.

B22—15 to 25 inches, brown (10YR 5/3, dry) silty clay loam, brown (10YR 4/3) when moist; moderate, coarse and medium, prismatic structure that breaks to moderate, fine and very fine, blocky; faces of blocks and prisms have a brown, shiny coating but when crushed are a light yellowish brown (10YR 6/4) when dry; hard when dry and friable when moist; many fine pores, channels, and worm casts; clear, wavy lower boundary.

B23—25 to 37 inches, pale-brown (10YR 6/3, dry) silty clay loam, brown (10YR 5/3) when moist; weak, coarse and medium, prismatic structure that breaks to weak, coarse and medium, blocky; faces of blocks are shiny; hard when dry, friable when moist; many small openings or channels plus worm casts; distinct, medium, yellowish-brown and gray mottles; some small to medium, iron and manganese concretions; many brown to black specks of iron or manganese; clear, wavy lower boundary.

B3—37 to 47 inches, pale-brown (10YR 6/3, dry) silty clay loam; weak, medium to coarse, prismatic structure that breaks to weak, coarse and medium, blocky; hard when dry, very friable when moist; entire matrix mottled with gray and yellowish brown so that basic color of matrix is hard to determine; many small and large iron stains and many rusty brown to black, small specks; gradual, irregular lower boundary.

C—47 to 60 inches, pale-brown (10YR 6/3, dry), light silty clay loam; slightly hard when dry, very friable when moist; weak, coarse, prismatic structure to massive; entire matrix so mottled with gray and yellowish brown that basic color is difficult to determine; many coarse, distinct mottles; many pores or small channels or openings throughout matrix; many small, brownish-black and black, iron and manganese specks; worm casts or insect workings scattered throughout matrix.

This soil profile is a good example of the Marshall soils in Washington County. It is also characteristic of the Marshall soils in Nebraska.

Most of the variations in the Marshall soils are in the thickness of the horizons, particularly the surface horizon.

McPaul series

The McPaul series consists of deep, medium-textured Alluvial soils. These soils occur along the nearly level, upland drains, where light-colored material from the uplands covers the dark bottom-land soils. A few areas, however, are along the edge of the river bottoms, where fans of light-colored wash from the uplands covered medium-textured bottom-land soils. The McPaul soils developed from overwash that was deposited on the Kennebec and Leshara soils. They developed in much the same way as Luton silt loam, overwash.

Profile of McPaul silt loam in a cultivated field (0.4 mile east and 100 feet south of the northwest corner of sec. 32, T. 20 N., R. 11 E.):

A1p—0 to 8 inches, dark grayish-brown (10YR 4.5/2, dry) silt loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; friable when moist, slightly hard when dry; noncalcareous; abrupt, smooth boundary.

A12—8 to 18 inches, very dark grayish-brown (10YR 3/2, dry) silt loam, black (10YR 2/1) when moist; moderate, fine, granular structure; friable when moist, slightly hard when dry; noncalcareous; clear, wavy boundary.

AC—18 to 30 inches, dark grayish-brown (10YR 4/2, dry) silt loam, very dark gray (10YR 3/1) when moist; moderate, medium, granular structure; friable when moist, slightly hard when dry; noncalcareous; clear, wavy boundary.

C—30 to 54 inches +, light brownish-gray (10YR 6/2, dry) very fine sandy loam, grayish brown (10YR 5/2) when moist; weak, fine, granular structure; very friable when moist, soft when dry; slight effervescence.

The dark surface soil in the profile described is a little deeper than that of most of the McPaul soils. Most of these soils have light-colored, recent alluvium, 1 to 2 feet thick, over the surface.

Monona series

Soils of the Monona series are medium-textured, well-drained minimal Brunizems of the loessal uplands. They occur on nearly level to steep slopes in the eastern one-third of the uplands and on the steep slopes between the nearly level uplands and the Elkhorn River bottom lands. In uneroded areas they have a moderately thick to thick silt loam surface horizon and a weakly developed, brown subsoil over a lighter colored, medium-textured, near-neutral substratum that is mottled in places.

Profile of Monona silt loam in a field of oats (0.2 mile west and 1,200 feet south of northeast corner of NW¼ sec. 18, T. 17 N., R. 12 E.; analytical data for this Monona profile in table 10):

A1p—0 to 6 inches, dark-brown (10YR 4/3, moist) silt loam; weak, very fine, crumb structure; slightly hard when dry, very friable when moist; many fine roots in this material; abrupt, smooth lower boundary.

A12—6 to 9 inches, very dark grayish-brown (10YR 3/2, moist) silt loam, crushed color is 4/2; moderate, fine and very fine, granular structure; slightly hard when dry, very friable when moist; full of worm casts and many fine openings or small channels; granules have thin, shiny, dark-brown coating.

B1—9 to 13 inches, dark grayish-brown (10YR 4.5/2, dry), heavy silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine and very fine, subangular blocky structure; slightly hard when dry, very friable when moist; dark shiny coatings on faces of blocks; worm casts numerous; many fine pores, openings, or channels; clear, wavy lower boundary.

B21—13 to 22 inches, brown (10YR 5/3, dry), heavy silt loam, dark brown (10YR 3.5/3) when moist; moderate, fine and very fine, subangular blocky structure; dark coatings on faces of blocks; hard when dry, very friable when moist; worm casts throughout this layer; many fine openings and channels; gradual, wavy lower boundary.

B22—22 to 34 inches, yellowish-brown (10YR 5/4, dry), light silty clay loam, dark yellowish brown (10YR 4/4) when moist; weak, coarse, prismatic structure that breaks to weak, fine and very fine, subangular blocky; worm casts and many fine openings or channels throughout; gradual, wavy lower boundary.

B3—34 to 48 inches, light yellowish-brown (10YR 6/4, dry) silt loam; moderate, coarse, prismatic structure that breaks to medium and fine, angular blocky; some worm casts and many fine openings and channels; common, distinct, gray and yellowish-brown mottles; few, dark, iron or manganese concretions throughout; gradual, wavy lower boundary.

C—48 to 60 inches, light yellowish-brown (10YR 6/4, dry) silt loam; weak, coarse, prismatic structure; shiny brown surfaces on faces of prisms; entire matrix has gray and yellowish-brown mottles, so that basic color is difficult to determine; mottles distinct and medium sized; matrix is full of fine pores or openings; some dark-brown concretions of iron; few, fine, manganese concretions throughout.

There is more evidence of horizonation in the profile described than in Monona soils on steeper slopes. The texture of the Monona soils ranges from silt loam to light silty clay loam. It varies from one horizon to another and from place to place within the county.

The Monona soils of this county are similar to those in other counties along the bluff zone of the Missouri River.

Moody series

The soils of the Moody series are moderately fine textured Chernozems that occur on the gently sloping to rolling loess of the uplands west of Bell Creek. They are well drained. The surface horizon is moderately thick to thick, moderately dark, and moderately fine textured. The subsoil is brown and is moderately fine textured. The yellowish-brown substratum is mottled in many areas. Also, the upper part is calcareous in many areas.

Profile of Moody silty clay loam in a field of small grain (0.1 mile east of southwest corner of SE¼ sec. 5, T. 19 N., R. 9 E.; analytical data for this Moody profile in table 10):

A1p—0 to 6 inches, very dark brown (10YR 2/2, dry) silty clay loam, dark brown (10YR 2/2) when moist; weak, very fine granular structure; slightly hard when dry, friable when moist; bottom part of plow layer very compact because of tillage; some worm casts and small pores throughout; many fine roots; clear, smooth lower boundary.

B1—6 to 10 inches, dark-brown (10YR 3/3, dry) silty clay loam, very dark grayish brown (10YR 3/2) when moist; crushed color is dark grayish brown (10YR 4/2); moderate, fine and very fine, granular structure; faces of granules coated with organic or colloidal material; hard when dry, friable when moist; worm casts numerous; clear, wavy lower boundary.

B21—10 to 22 inches, dark-brown (10YR 3/3, moist) silty clay loam; moderate, coarse, prismatic structure that breaks to moderate, fine and very fine, angular blocky; hard when dry, firm when moist; faces of blocks and prisms are shiny and have some dark organic stainings; numerous worm casts and many very fine pores; gradual, wavy lower boundary.

B22—22 to 32 inches, dark grayish-brown (2.5Y 4/2, moist) silty clay loam; weak, coarse, prismatic structure that breaks to weak, medium and fine, blocky; hard when dry, firm when moist; entire matrix mottled with gray and yellowish brown; many, medium, distinct mottles; worm casts and fine pores throughout; some iron stains and small manganese specks; gradual, wavy boundary.

B3—32 to 42 inches, light olive-brown (2.5Y 5/4, moist) silty clay loam; weak, coarse, prismatic structure that breaks to weak, coarse and medium, blocky; slightly hard when dry, friable when moist; many, medium, prominent mottles, as the entire matrix is about half gray and half yellowish-brown mottles; faces of prisms and blocks have shiny colloidal coating; numerous fine to medium-sized manganese and iron stains; fine pores and channeling throughout matrix; many soft, rusty brown iron concretions; gradual, wavy lower boundary.

C—42 to 60 inches, light yellowish-brown (2.5Y 6/4, dry), light silty clay loam or heavy silt loam, light olive brown (2.5Y 5/4) when moist; weak, coarse, prismatic structure to massive (structureless); slightly hard when dry, very friable when moist; many, prominent, yellowish-brown and gray mottles; entire matrix is so mottled that it is difficult to tell basic color; full of pores and fine channels; many rusty brown iron stains and some nearly black manganese stains and concretions; borings were made to a depth of about 90 inches; many soft iron concretions at a depth of 63 to 64 inches, but matrix was not calcareous until a depth of 72 to 74 inches.

This soil profile is a good example of the Moody soils of Washington County. It is more leached, however, and has a higher clay content than the Moody soils of northeast Nebraska. In places the matrix is calcareous at 78 inches. Lime concretions also occur at that depth. The depth to lime and the thickness and color of the surface horizon vary with the slope and amount of erosion.

Nora series

The Nora soils are deep, well drained, and moderately fine textured to medium textured. They are Chernozems that occur in the rolling uplands of the western two-thirds of the county. They have weak to moderate horizonation and have developed in calcareous loess. The Nora soils are moderately to severely eroded and have a thin to moderately thick surface horizon. The substratum is calcareous; the lower part of the subsoil may also be calcareous.

Profile of Nora silty clay loam in a cultivated field (0.2 mile south and 75 feet west of the northeast corner of sec. 30, T. 17 N., R. 11 E.):

Alp—0 to 8 inches, dark grayish-brown (10YR 4/2, dry), light silty clay loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; abrupt, smooth boundary.

B2—8 to 19 inches, brown (10YR 5/3, dry), light silty clay loam, dark brown (10YR 4/3) when moist; moderate, medium, granular structure; slightly hard when dry, friable when moist; noncalcareous; clear, wavy boundary.

B3—19 to 24 inches, light olive-brown (2.5Y 5/3, dry), light silty clay loam, olive brown (2.5Y 4/4) when moist; weak, coarse, prismatic structure that breaks to weak, fine and medium, subangular blocky; slightly hard when dry, friable when moist; a few, faint, fine, yellowish-brown mottlings; noncalcareous; clear, wavy boundary.

C1—24 to 36 inches, light yellowish-brown (2.5Y 6/3, dry) silt loam, light olive brown (2.5Y 5/4) when moist; weak, fine, subangular blocky structure or massive (structureless); soft when dry, very friable when moist; strong effervescence; gradual, wavy boundary.

C2—36 to 60 inches, light brownish-gray (2.5Y 6/2, dry) silt loam, grayish brown (2.5Y 5/2) when moist; massive (structureless); soft when dry, very friable when moist; strong effervescence.

The thickness of the surface horizon and the depth to lime vary with the slope and the degree of erosion.

Onawa series

The Onawa series consists of light-colored Alluvial soils that have developed in recent stream deposits on the low bottom lands along the Missouri River. These soils have a fine-textured surface horizon and subsoil. The substratum is medium to moderately coarse textured. The Onawa soils are calcareous and somewhat poorly drained.

Profile of Onawa clay in a cultivated field (0.25 mile west of the northeast corner of sec. 18, T. 17 N., R. 13 E.):

Alp—0 to 10 inches, grayish-brown (10YR 5/2, dry) clay, dark grayish brown (10YR 4/2) when moist; moderate, fine, granular structure; firm when moist, hard when dry; calcareous; clear, smooth boundary.

AC—10 to 18 inches, light brownish-gray (10YR 6/2, dry) silty clay, grayish brown (10YR 5/2) when moist; moderate, fine, granular structure; firm when moist, hard when dry; calcareous; clear, smooth boundary.

C1—18 to 26 inches, light brownish-gray (2.5Y 6/2, dry) very fine sandy loam, grayish brown (2.5Y 5/2) when moist; weak, coarse, subangular blocky structure; very friable when moist, soft when dry; calcareous; gradual, smooth boundary.

D—26 to 42 inches, light brownish-gray (2.5Y 6/2, dry), stratified, light very fine sandy loam and sandy loam; weak, coarse, subangular blocky structure; very friable when moist; calcareous; common, yellowish-brown and dark reddish-brown mottles.

The D horizon occurs between 20 and 40 inches below the surface and varies in texture. Dark buried soils and stratified sand and clay underlie the Onawa soils in places.

Rauville series

The Rauville series consists of poorly drained, wet soils that have developed in recent alluvial deposits along the Elkhorn and Missouri Rivers. They are in nearly level, backwater depressions or old shallow channels where water collects and stands. These soils are in the Humic Gley group. They have a dark surface horizon and a mottled or gleyed, stratified substratum.

Profile of Rauville clay (0.4 mile south and 100 feet east of the northwest corner of sec. 17, T. 17 N., R. 13 E.):

A1—0 to 8 inches, very dark gray (10YR 3/1, dry) clay, black (10YR 2/1) when moist; weak, medium and fine, granular structure; very sticky when wet; slight effervescence; abrupt, smooth boundary.

A12—8 to 16 inches, dark-gray (10YR 4/1, dry) clay, very dark grayish brown (10YR 3/2) when moist; moderate, medium and very fine, granular structure; very sticky when wet; strong effervescence; clear, wavy boundary.

C—16 to 24 inches, gray (5Y 5/1, dry) silty clay, dark gray (5Y 4/1) when moist; strong, medium and fine, subangular blocky structure; sticky when wet; strong effervescence; clear, wavy boundary; wet, containing free water; gray and yellowish-brown mottles.

D—24 to 48 inches, light olive-gray (5Y 6/2, dry) silt loam or very fine sandy loam, olive gray (5Y 4/2) when moist; massive (structureless); nonplastic when wet; strong effervescence.

The texture of these soils varies greatly because of the stratification of the parent material. Fine textures predominate, but some sandy areas have been included.

Salix series

The Salix series consists of well-drained soils that developed in medium-textured alluvium on the natural levee near the edge of the high bottom lands along the Missouri River. As these soils are on a ridge, they are flooded less frequently than the Haynie and associated soils. They are more leached than the other bottom-land soils and have soil horizons that are more distinct. The Salix are classed as Alluvial soils, but they could be considered Alluvial-Brunizem intergrades.

Profile of a Salix silt loam in a cultivated field (0.1 mile north and 50 feet west of the southeast corner of sec. 36, T. 19 N., R. 11 E.):

A1p—0 to 6 inches, grayish-brown (10YR 5/2, dry) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; very friable when moist; noncalcareous; abrupt, smooth boundary.

A12—6 to 12 inches, dark grayish-brown (10YR 4/2, dry) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine, granular structure; very friable when moist; noncalcareous; clear, smooth boundary.

AC or B—12 to 20 inches, brown (10YR 5/3, dry) silt loam, dark grayish brown (10YR 4/2.5) when moist; weak, coarse, prismatic structure; very friable when moist; noncalcareous; gradual, wavy boundary.

C1—20 to 42 inches, pale-brown (10YR 6/3, dry) silt loam, yellowish brown (10YR 5/4) when moist; weak, coarse, prismatic structure; very friable when moist; strong effervescence; gradual, wavy boundary.

C2—42 inches +, pale-brown (10YR 6/3, dry) silt loam, brown (10YR 5/3) when moist; weak, coarse, prismatic structure; very friable when moist; strong effervescence.

Sand may be present at 5 to 6 feet below the surface. In places the lower part of the profile is a very fine sandy loam or sandy loam.

Sarpy series

The Sarpy series consists of light-colored, coarse-textured Alluvial soils. These soils occur on low bottom lands of the Missouri and Elkhorn Rivers. Most areas of Sarpy soils are nearly level. In places, however, the loamy sand type is on low ridges and hummocks. These soils are immature and calcareous. They are permeable but may have a water table 2 to 10 feet below the surface.

Profile of Sarpy loam in native vegetation (0.3 mile south and 100 feet east of the northwest corner of sec. 10, T. 17 N., R. 13 E.):

A1—0 to 8 inches, grayish-brown (2.5Y 5/2, dry) loam, very dark grayish brown (2.5Y 3/2) when moist; moderate, fine and very fine, granular structure; slightly hard when dry, very friable when moist; strongly calcareous; clear, smooth boundary.

C1—8 to 20 inches, light brownish-gray (10YR 6/2, dry) loamy fine sand, grayish brown (10YR 5/2) when moist; loose structure and single grain; weakly calcareous; gradual, irregular boundary.

C2—20 to 48 inches, light brownish-gray (10YR 6/2, dry) fine sand, brown (10YR 5/3) when moist; loose structure and single grain; weakly calcareous.

The texture of the underlying material ranges from a fine sand to a loamy sand.

Sharpsburg series

The soils of the Sharpsburg series are deep, dark, moderately fine textured Brunizems. They have developed on nearly level to rolling slopes in the loessal uplands of the central part of the county. In general, these soils are well drained and have moderate to strong horizonation. The subsoil is distinctly finer textured than the surface horizon and substratum. Sharpsburg soils are noncalcareous throughout the solum.

Profile of Sharpsburg silty clay loam in a cultivated field of wheat (350 feet north and 100 feet west of southeast corner of SW¼ sec. 28, T. 19 N., R. 10 E.; analytical data for this Sharpsburg profile in table 10):

A1p—0 to 5 inches, dark grayish-brown (10YR 4/1.5, dry), heavy silt loam, very dark brown (10YR 2/2) when moist; weak, subangular blocky structure that breaks to moderate, very fine granular; friable when moist, slightly hard when dry; abundant roots; no effervescence; abrupt, smooth boundary.

A12—5 to 12 inches, dark grayish-brown (10YR 3.5/2, dry), light silty clay loam that crushes to 10YR 3/3 when moist, very dark brown (10YR 2/1.5) when moist; moderate, fine, granular structure; friable when moist, slightly hard when dry; abundant roots; many fine pores and numerous worm casts; a few, scattered, ⅛-inch shotlike concretions of iron and manganese; no effervescence; clear, smooth boundary.

B1—12 to 16 inches, dark grayish-brown (10YR 4/2, dry) silty clay loam that crushes to dark brown (10YR 3/3) when moist, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky structure that breaks to moderate, fine, granular; patchy coating on aggregates; roots plentiful; few worm casts; no effervescence; few 1/16- to ⅛-inch, very dark brown shotlike concretions; clear, smooth boundary.

B21—16 to 24 inches, dark grayish-brown (10YR 4/2, dry) silty clay loam that crushes to 10YR 4/3 when moist, very dark brown (10YR 3.5/3) when moist; weak, medium, subangular blocky structure that breaks to moderate, fine, granular; slightly firm when moist, hard when dry; roots plentiful; few, very fine pores; occasional 1/16-inch, very dark brown shotlike concretions; no effervescence; clear, smooth boundary.

B22—24 to 36 inches, grayish-brown (10YR 5/2.5, dry) silty clay loam, dark grayish brown (10YR 4/2.5) when moist; weak, coarse, prismatic structure that breaks to moderate, fine, subangular blocky; slightly firm when moist, hard when dry; thin and continuous aggregate coatings; some dark, thick coatings on faces of prisms; roots common but tend to follow faces of subangular blocks; few, faint, fine, yellowish-brown mottles; no effervescence; gradual, smooth boundary.

B3—36 to 48 inches, grayish-brown (2.5Y 5.5/2, dry) silty clay loam, dark grayish brown (2.5Y 4/2) when moist; weak, coarse, prismatic structure that breaks to weak, medium and fine, subangular blocky; friable when moist, slightly hard when dry; few roots; many fine and very fine pores; common, distinct, fine, yellowish-brown mottles; a few soft, prominent, very dark brown, iron-manganese concretions; no effervescence; gradual, smooth boundary.

C—48 to 60 inches, grayish-brown (2.5Y 5.5/2, dry) silty clay loam, grayish brown (2.5Y 5/2.5) when moist; weak, coarse, prismatic structure that breaks to weak, subangular blocky; very friable when moist, soft when dry; numerous, fine and very fine pores; common, distinct, fine, yellowish-brown mottles; a few, fine, prominent, very dark brown, soft iron-manganese concretions; no roots; no effervescence.

The profile described is typical of the Sharpsburg soils in Washington County but has a B horizon that is minimal in clay content and structure when compared with Sharpsburg soils in southeastern Nebraska.

The thickness of the surface horizon varies according to the slope of the soil and its position in the landscape. This horizon is thickest in the swales and thinnest on the ridges. The more level areas have the strongest, or most distinct, structure in their subsoil.

Steinauer series

The Steinauer series consists of thin soils developed in calcareous, clayey glacial till on steep slopes. These soils are Regosols and are calcareous at or near the surface. Small amounts of stone and gravel are scattered throughout the profile and have accumulated on the surface of eroded spots.

Profile of Steinauer clay loam in a cultivated field:

A1p—0 to 5 inches, grayish-brown (10YR 5/2, dry) clay loam, very dark grayish brown (10YR 3/2) when moist; weak to moderate, fine, granular structure; friable when moist, hard when dry; violent effervescence; abrupt, smooth boundary.

A12—5 to 6 inches, brown (10YR 5/3, dry) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, medium, subangular blocky to moderate, fine, granular structure; friable when moist, hard when dry; violent effervescence; clear, wavy boundary.

AC—6 to 9 inches, light yellowish-brown (10YR 6/4, dry) clay loam, brown (10YR 5/3) when moist; weak, coarse, subangular blocky structure that breaks to moderate, fine, subangular blocky; friable when moist, hard when dry; violent effervescence; many, medium, prominent, yellowish-brown to brown mottles; few iron and lime concretions; worm casts and channels throughout the matrix; clear, wavy boundary.

C1—9 to 20 inches, light olive-gray (5Y 6/2, dry) clay loam, olive gray (5Y 5.5/2) when moist; moderate, fine, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; few, fine, faint, yellowish-brown mottles; disseminated lime and lime and iron concretions; clear, wavy boundary.

C2—20 to 60 inches, light olive-gray (5Y 6/2, dry) clay loam, olive gray (5Y 5.5/2) when moist; moderate, medium, blocky structure to massive (structureless); friable when moist, hard when dry; numerous, fine and medium lime concretions.

Because the parent glacial material varies, there is considerable variation in the Steinauer soils. As a result of severe erosion, the surface soil is usually thin. Small, gravelly areas that are low in lime have been included with this soil.

Volin series

The Volin series consists of well drained to moderately well drained Alluvial soils that have developed in silty sediments on the high bottom lands along the Missouri River. These soils have weak horizonation, are commonly calcareous below the surface horizon, and may be mottled in the substratum.

Profile of Volin silt loam in a cultivated field (0.4 mile south and 100 feet east of the center of sec. 13, T. 19 N., R. 11 E.):

A1p—0 to 8 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, very fine, granular structure; very friable when moist; slightly calcareous; abrupt, smooth boundary.

A12—8 to 12 inches, gray (10YR 5/1) silt loam, very dark gray (10YR 3/1) when moist; weak, medium and fine, granular structure; very friable when moist; slightly calcareous; clear, wavy boundary.

AC—12 to 15 inches, grayish-brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, medium and fine, granular structure; very friable when moist; strongly calcareous; gradual, wavy boundary.

C1—15 to 24 inches, light brownish-gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) when moist; weak, fine, blocky structure; very friable when moist; strongly calcareous; clear, wavy boundary.

C2—24 to 44 inches, light brownish-gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) when moist; weak, very fine, granular structure; very friable when moist; strongly calcareous; clear, wavy boundary.

C3—44 to 60 inches, light-gray (2.5Y 7/2) very fine sandy loam, light brownish gray (2.5Y 6/2) when moist; single grain; very friable when moist; violent effervescence.

Dark buried horizons are not uncommon in the substratum of the Volin soils. Stratified layers of sand and silt occur in many places below 3 feet.

Mechanical and Chemical Analyses

The data obtained by mechanical and chemical analyses for selected soils in Washington County are given in table 10. The data in table 10 are useful to soil scientists in classifying soils and in developing concepts of soil genesis. They are also helpful for estimating water-holding capacity, wind erosion, fertility, tilth, and other practical aspects of soil management. The data on reaction, electrical conductivity, and percentage of exchangeable sodium are helpful in evaluating the possibility of reclaiming and managing saline-alkali areas.

Profiles of the soils listed in table 10 are described in the section "Genesis, Classification, and Morphology of Soils."

Field and Laboratory Methods

All samples used to obtain the data in table 10 were collected from carefully selected pits. The samples are considered representative of the soil material that is made up of particles less than three-quarter inch in diameter. Estimates of the fraction of the sample consisting of particles larger than three-quarter inch were made during the sampling. If necessary, the sample was sieved after it was dried and rock fragments larger than three-quarter inch in diameter were discarded. Then the material made up of particles less than three-quarter inch in size was rolled, crushed, and sieved by hand to remove rock fragments larger than 2 millimeters in diameter. Only two of the horizons sampled, the two deepest horizons of the Luton clay soil, contained even a trace of rock fragments between 2 millimeters and three-quarter inch in diameter.

Unless otherwise noted, all laboratory analyses are made on material that passes the 2-millimeter sieve and are reported on an oven-dry basis. In table 10, values for exchangeable sodium and potassium are for amounts of sodium and potassium that have been extracted by the ammonium acetate method, minus the amounts that are soluble in the saturation extract.

TABLE 10.—*Analytical data*

[Analysis made at Soil Survey Laboratory, Soil Conservation Service

Soil	Horizon	Depth	Particle size distribution						
			Very coarse sand (2–1 mm.)	Coarse sand (1–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.10 mm.)	Very fine sand (0.10–0.05 mm.)	Silt (0.05–0.002 mm.)	Clay (<0.002 mm.)
		Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Belfore silty clay loam: *Location:* 400 feet west and 100 feet south of NE. corner of NW¼ sec. 3, T. 18 N., R. 9 E. west of Bell Creek (*Sample* No. S–57–Nebr-89–7; *laboratory* No. 6299–6305).	Alp	0–6	[1] 0. 1	---	---	[2] 0. 1	[2] 3. 6	63. 9	32. 3
	A12	6–9	---	---	---	[2] . 1	[2] 3. 4	61. 8	34. 7
	B1	9–14	---	---	---	---	[2] 3. 5	59. 3	37. 2
	B21	14–20	---	---	---	---	[2] 4. 3	59. 3	36. 4
	B22	20–30	---	---	---	[2] . 1	[2] 5. 3	61. 4	33. 2
	B23	30–42	---	---	---	[2] . 1	[2] 5. 3	62. 3	32. 3
	C	42–60	---	---	---	[2] . 1	[2] 5. 2	63. 3	31. 4
Luton clay: *Location:* 300 feet east and 100 feet south of NW. corner, sec. 10, T. 19 N., R. 11 E. (*Sample* No. S–57–Nebr–89–2; *laboratory* No. 6263–70).	Alp	0–5	---	[1] 0. 1	---	. 1	. 6	37. 5	61. 7
	A12	5–9	---	---	---	[3] . 1	[3] . 4	28. 4	71. 1
	Alb	9–12	---	---	---	---	. 3	27. 9	71. 8
	Cb	12–16	---	---	---	[4] . 1	[4] . 4	26. 3	73. 2
	Alb2	16–26	---	---	---	---	[5] . 4	32. 4	67. 2
	Cb2	26–38	. 1	. 1	---	[5] . 1	[5] . 3	26. 0	73. 4
	Alb3 [6]	38–46	---	---	---	[5] . 1	[5] . 4	34. 6	64. 9
	Cgca [6]	46–60	[3] . 4	[3] . 7	[3] . 2	[3] . 2	[3] . 2	35. 1	63. 2
Marshall silty clay loam: *Location:* 450 feet west and 110 feet north of SE. corner of SW¼ sec. 29, T. 17 N., R. 11 E. (*Sample No.* S–57–Nebr–89–8; *laboratory No.* 6306–11).	Alp	0–7	[1] . 1	[1] . 1	---	[7] . 1	[7] 1. 8	67. 2	30. 7
	B21	7–15	---	---	---	[7] . 1	[7] 1. 9	64. 3	33. 7
	B22	15–25	---	---	---	[7] . 1	[7] 3. 2	64. 6	32. 1
	B23	25–37	---	---	---	[7] . 1	[7] 2. 7	67. 3	29. 9
	B3	37–47	---	---	---	[7] . 1	[7] 2. 8	67. 9	29. 2
	C	47–60	---	---	---	[7] . 1	[7] 3. 4	68. 5	28. 0
Monona silt loam: *Location:* 0.2 mile west and 1,200 feet south of NE. corner of NW¼ sec. 18, T. 17 N., R. 12 E; this is about 400 feet east and 100 feet north of center of NW¼, on ridge-top and 4½ miles west and ½ mile south of Fort Calhoun, Nebr. (*Sample No.* S–57–Nebr–89–10; *laboratory No.* 6319–25).	A1p	0–6	---	---	---	---	[8] 1. 3	74. 0	24. 7
	A12	6–9	---	---	---	---	[8] 1. 2	72. 9	25. 9
	B1	9–13	---	---	---	. 1	[8] 1. 0	74. 1	24. 8
	B21	13–22	---	---	---	---	[8] 1. 1	74. 7	24. 2
	B22	22–34	---	---	---	[8] . 1	[8] 1. 7	73. 1	25. 1
	B3	34–48	---	---	---	[8] . 1	[8] 2. 1	72. 6	25. 2
	C	48–60+	---	---	---	[8] . 2	[8] 2. 3	72. 2	25. 3
Moody silty clay loam: *Location:* 0.1 mile east of SW. corner of SE¼ sec. 5, T. 19 N., R. 9 E. west of Bell Creek (*Sample No.* S–57–Nebr–89–11; *laboratory No.* 6326–31).	Alp	0–6	. 2	. 1	. 1	. 2	[9] 3. 4	59. 9	36. 1
	B1	6–10	---	---	---	---	[9] 3. 2	58. 6	38. 2
	B21	10–22	---	---	---	[9] . 1	[9] 3. 1	62. 3	34. 5
	B22	22–32	---	---	---	[9] . 1	[9] 3. 3	64. 7	31. 9
	B3	32–42	---	. 1	---	[9] . 1	[9] 2. 8	65. 1	31. 9
	C	42–60	---	---	---	[9] . 3	[9] 3. 6	66. 6	29. 5
Sharpsburg silty clay loam: *Location:* 350 feet north and 100 feet west of SE. corner of SW¼ sec. 28 T. 19 N., R. 10 E. (*Sample No.* S–57–Nebr–89–4; *laboratory No.* 6278–84).	Alp	0–5	---	[1] . 1	---	---	1. 5	66. 5	31. 9
	A12	5–12	[10] . 2	[10] . 2	[10] . 1	[10] . 1	[10] 1. 1	64. 7	33. 6
	B1	12–16	[10] . 3	[10] . 3	[10] . 2	[10] . 2	[10] . 9	62. 2	35. 9
	B21	16–24	[10] . 2	[10] . 3	[10] . 2	[10] . 2	[10] 1. 1	60. 0	38. 0
	B22	24–36	---	[10] . 3	[10] . 2	[10] . 3	[10] 2. 1	61. 1	36. 0
	B3	36–48	---	[10] . 1	[10] . 2	[10] . 3	[10] 2. 6	62. 6	34. 2
	C	48–60	---	[10] . 1	[10] . 1	[10] . 2	[10] 3. 0	65. 1	31. 5

[1] Contains organic matter.
[2] Contains common, smooth, brown concretions (Fe-Mn).
[3] Contains few $CaCO_3$ concretions.
[4] Contains few, irregular, black concretions (Mn), also few $CaCO_3$ concretions.
[5] Contains common, smooth, light-brown concretions (Fe), also few $CaCO_3$ concretions.

for selected soil profiles

Lincoln, Nebr. Dashes indicate values not determined]

Texture	Chemical analysis: Reaction (saturated paste)	Organic carbon	Estimated salt	Electrical conductivity (EC × 10^3 millimhos per cm. at 25° C.)	$CaCO_3$ equivalent	Cation exchange capacity (NH_4Ac)	Extractable cations (meq. per 100 gm. soil): Ca	Mg	H	Na	K	Exchangeable sodium percentage	Volume by weight
	pH	*Percent*	*Percent*		*Percent*								*Gms./cc.*
Silty clay loam	5.7	2.01	----	----	----	23.0	12.8	4.0	12.2	----	1.0	----	----
Silty clay loam	5.7	1.82	----	----	----	24.6	13.9	4.8	11.5	----	.7	----	----
Silty clay loam	6.0	1.45	----	----	----	25.6	15.6	5.8	9.6	0.1	.6	----	----
Silty clay loam	6.3	.81	----	----	----	25.5	16.1	7.0	7.6	.1	.6	----	----
Silty clay loam	6.5	.50	----	----	----	24.8	16.0	6.9	5.6	.1	.5	----	1.34
Silty clay loam	6.7	.27	----	----	----	24.8	16.9	7.0	4.8	.1	.6	----	----
Silty clay loam	6.8	.17	----	----	----	25.4	17.5	6.5	4.0	.2	.6	----	1.34
Clay	7.8	1.57	<0.20	0.7	2	39.8	40.7	8.8	2.1	.1	1.8	----	----
Clay	7.9	.92	<.20	.5	2	41.0	46.0	10.8	3.0	.3	1.0	1	1.26
Clay	7.8	1.10	<.20	.5	1	46.1	39.9	12.8	3.4	.4	.7	1	----
Clay	7.7	.74	<.20	.6	2	44.8	40.9	13.3	2.9	.4	1.0	1	----
Clay	7.6	1.30	<.20	.9	----	45.9	32.6	16.9	2.9	1.1	1.2	2	1.22
Clay	7.6	.68	<.20	1.1	2	46.1	35.8	15.4	2.9	.7	1.1	1	1.17
Clay	7.6	1.31	<.20	1.0	1	47.8	34.1	18.1	3.4	1.4	.8	2	----
Clay	7.8	.79	<.20	1.0	3	43.5	37.0	17.2	2.1	1.3	.8	2	----
Silty clay loam	6.2	1.64	----	----	----	23.3	14.0	4.9	9.1	----	.8	----	----
Silty clay loam	6.3	.84	----	----	----	24.5	15.9	6.2	8.8	.1	.5	----	----
Silty clay loam	6.5	.43	----	----	----	24.2	15.9	6.5	6.0	.1	.5	----	1.26
Silty clay loam	6.7	.23	----	----	----	23.8	16.6	6.3	5.6	.1	.4	----	----
Silty clay loam	6.8	.17	----	----	----	23.9	16.8	6.3	4.4	.2	.4	----	----
Silty clay loam	6.9	.13	----	----	----	23.6	17.2	6.4	3.6	.3	.4	----	1.23
Silt loam	5.6	1.73	----	----	----	19.5	10.3	3.6	11.0	----	.7	----	----
Silt loam	6.0	1.62	----	----	----	20.3	10.8	3.7	9.8	.1	.3	----	----
Silt loam	6.3	1.33	----	----	----	19.9	11.7	4.2	8.2	.1	.3	----	----
Silt loam	6.3	.94	----	----	----	19.6	12.0	4.6	7.5	.1	.3	----	----
Silt loam	6.5	.46	----	----	----	21.5	13.5	5.5	5.5	.1	.3	----	1.26
Silt loam	6.7	.23	----	----	----	20.8	14.4	5.6	4.8	.2	.3	----	----
Silt loam	6.8	.12	----	----	----	21.8	15.0	5.7	4.3	.2	.4	----	1.24
Silty clay loam	6.1	2.01	----	----	----	27.0	15.9	6.0	10.3	----	1.0	----	----
Silty clay loam	6.3	1.13	----	----	----	29.0	17.5	7.2	7.6	.1	.7	----	----
Silty clay loam	6.5	.63	----	----	----	26.2	16.9	7.6	6.8	.1	.5	----	1.34
Silty clay loam	6.7	.31	----	----	----	24.8	16.2	7.2	5.6	.1	.5	----	----
Silty clay loam	6.8	.21	----	----	----	25.1	16.8	7.5	3.6	.2	.5	----	----
Silty clay loam	6.8	.14	----	----	----	24.5	16.4	7.3	3.6	.2	.5	----	1.31
Silty clay loam	5.8	2.14	----	----	----	24.1	13.6	5.2	10.9	----	1.5	----	----
Silty clay loam	6.1	2.11	----	----	----	25.1	14.9	5.6	9.9	----	.8	----	1.28
Silty clay loam	6.5	1.47	----	----	----	26.1	15.8	6.5	7.9	----	.5	----	----
Silty clay loam	6.6	.91	----	----	----	29.0	17.9	8.1	6.7	----	.5	----	----
Silty clay loam	6.7	.48	----	----	----	28.4	18.0	7.9	5.9	.1	.4	----	1.46
Silty clay loam	6.7	.26	----	----	----	28.2	18.1	7.9	6.1	.1	.5	----	----
Silty clay loam	6.8	.18	----	----	----	26.7	17.6	7.5	5.2	.2	.5	----	1.30

[6] Trace of particles larger than 2 millimeters in this horizon.
[7] Contains common, smooth, brown concretions (Fe-Mn).
[8] Contains few, irregular, light-brown concretions (Fe-Mn).
[9] Contains common, irregular, light-brown and black concretions (Fe-Mn).
[10] Many smooth, brown, porous concretions (Fe).

Standard methods of the Soil Survey Laboratory were used to obtain most of the data in table 10. Determinations of clay were made by the pipette method (*5*, *6*, *8*). The reaction of the saturated paste was measured with a glass electrode. Organic carbon was determined by wet combustion, using a modification of the Walkley-Black method (*9*). The calcium carbonate equivalent was determined by measuring the volume of carbon-dioxide emitted from soil samples treated with concentrated hydrochloric acid. The cation exchange capacity was determined by direct distillation of absorbed ammonia (*9*). To determine the extractable calcium and magnesium, calcium was separated as calcium oxalate, and magnesium as magnesium ammonium phosphate (*9*). Extractable sodium and potassium were determined on original extracts with a flame spectrophotometer. The methods of the U.S. Salinity Laboratory were used to obtain the saturation extract (*10*). Soluble sodium and potassium were determined on the saturation extract with a flame spectrophotometer.

General Nature of the County

This section was prepared mainly for those not familiar with the county. Some of the general characteristics of the county are discussed. These include early history; physiography, relief, and drainage; native vegetation; climate; transportation facilities; industries; and agriculture.

Early History

Some of the earliest settlements in the State were made in the area now comprising Washington County. The first white residents were hunters, trappers, explorers, and soldiers. On August 3, 1804 the explorers, Lewis and Clark, held a council with the Indians near the present site of Fort Calhoun. The first steamboat up the Missouri River landed in September 1819, near the site of Fort Calhoun. It carried troopers from the New Hampshire rifle regiment, who were sent out to establish the Fort Atkinson Military Post. This post was needed for the protection of the settlers and was located on the bluffs along the Missouri River, east of the site of Fort Calhoun. At that time the river channel was at the base of the bluffs. After much flooding and engineering work in the valley, the river is now located 2 to 4 miles northeast and east of where it flowed at the time the fort was established. This change in the river course made a large area of the bottom lands available for farming.

The present town of Fort Calhoun was the first settlement in the county. Most of the settlers came from Iowa, Missouri, Illinois, Indiana, and Ohio. When the settlers came, there was mainly native prairie. Along the streams and bluffs, however, trees predominated.

The first extensive farming in Nebraska took place in Washington County. In 1820 and 1821 soldiers stationed at Fort Atkinson, near the present town of Fort Calhoun, cultivated several hundred acres of the terrace land along the Missouri River. The corn and wheat that were produced were used at Fort Atkinson.

In 1855 Washington County was organized within its present boundaries. The population was 207.

Physiography, Relief, and Drainage

Washington County is divided into two distinct, topographic areas: (1) The bottom lands along the Missouri and Elkhorn Rivers, and (2) the uplands between these two rivers. Some of these areas can be further subdivided. The Missouri River bottom lands consist of two levels—the low bottom lands, which are generally near the river, and the high bottom lands between the uplands and the low bottom lands.

The low bottom lands are imperfectly drained and were flooded frequently before the large mainstem dams were built on the river. The high bottom lands are well drained and were seldom flooded. Recent channel work has stabilized the course of the river in places so that the present stream may go through some formerly high bottom-land areas.

The uplands are part of a dissected plain that makes up eastern Nebraska. Bedrock of the upper Pennsylvanian sediments underlies the extreme southeastern corner of the county. Sandstone and shale of the Dakota group (lower Cretaceous) underlie the rest of the county. Over the bedrock is glacial material of Nebraskan and Kansan age. The upper till is of Kansan age and is clay loam in texture. It is exposed along the most deeply entrenched streams. Loess mantles all of the uplands and stream terraces and in places is as much as 100 feet thick. The brown to reddish-brown silty to clayey material of Loveland age that covers the till surface is 1 to several feet thick. The gray, calcareous Peorian loess that covers all of the uplands and stream terraces averages 40 feet in thickness. A discontinuous covering of younger, yellowish-brown, slightly calcareous loess, 20 feet or more thick, occurs on ridgetops and terraces along the Missouri River. This material becomes thinner westward. These recent loess deposits are thickest on the southern and eastern sides of the ridges and on the level terraces and uplands.

The uplands can be divided into three parts: (1) The level, loess-covered stream terraces along the Missouri River and Bell Creek and the level upland divides; (2) the gently sloping to rolling uplands in the central part of the county; and (3) the rolling to steeply rolling uplands and the bluff zone in the eastern part of the county.

The bottom lands of the county are from 100 to 300 feet below the uplands. The lowest elevation, approximately 1,000 feet above sea level, is along the Missouri River in the southeastern corner of the county.

The uplands in the northwestern corner are about 1,320 feet above sea level. The county slopes to the southeast. Bell Creek is about 120 feet, and Papillion Creek 150 to 200 feet, below the uplands. The Missouri River is about 300 feet below the upland divide that lies between it and Papillion Creek. Blair, on the Missouri River terrace, is 1,122 feet above sea level.

All of the drainage in the county goes directly or indirectly into the Missouri River. The Missouri River bottom lands and the bluff zone drain directly into the Missouri River. The central part of the county is drained by Papillion Creek, which flows into the Missouri River south of Omaha. The western part of the county is drained by the Elkhorn River and Bell Creek, which flows into the Elkhorn River near the southwestern corner of the county. The Elkhorn River flows into the Platte River, which flows into the Missouri River.

Native Vegetation

On the bottom lands and bluffs near the Missouri and Elkhorn Rivers and their major tributaries, the native vegetation was trees. On the level and rolling uplands, it was tall prairie grass. The principal native trees were bur oak, red oak, ash, American elm, hackberry, and walnut. On the wetter sites and on the lower slopes, cottonwood and willow trees were the most common.

The principal native grasses were big bluestem, switchgrass, and Indiangrass. Little bluestem, side-oats grama, and prairie dropseed grew on the drier, steeper slopes. Prairie cordgrass, switchgrass, and gamagrass were some of the most common grasses on wet bottom lands.

There is very little, if any, land in the county that still has an undisturbed cover of grass or trees. Use or management of native areas of grasses and woodlands has changed the composition of the original native cover to varying degrees.

Climate [7]

Washington County has the typical climate of the interior of large continents in middle latitudes. Some of the main characteristics of such a climate are rather light rainfall, hot summers, severe winters, great annual variations in temperature and rainfall, and frequent daily or weekly changes in weather.

Weather observations made at the U.S. Weather Bureau Stations at DeSoto from 1867 to 1895 and at Blair, 5 miles northwest of DeSoto, from 1896 to 1961, were summarized in tables 11, 12, 13, and 14. These tables show, respectively, the monthly and seasonal temperature and precipitation at Blair; the amount of precipitation during the 10 driest years; the amount of precipitation during the 10 wettest years; and data on the wettest and driest months.

[7] Prepared by W. R. Stevens, State climatologist, Nebraska, U.S. Weather Bureau.

Data in these tables show the great variability and severity of the climate. For example, the difference in average temperature between the coldest month (January) and the warmest month (July) is 55.1° F. at Blair (table 11). The difference between the lowest and highest temperatures on record at Blair is 152°.

The average annual range in temperature at Blair is approximately 117°. The range has exceeded 128° in a few years and has reached a high of 140°. Temperatures above 100° have been recorded in the 5 months, May through September; and temperatures below 0° have been recorded in the 5 months, November through March.

The coldest month on record at Blair was February 1936 when the average temperature was 5.4° F. The minimum temperature was zero, or below, from February 1 through February 22. The lowest temperature during that period was −22°. In fact, minimum temperatures were zero, or below, from January 18 through February 22, a total of 36 days. This was the longest period of such low temperatures at the Blair station. Maximum temperatures did not reach as high as the freezing point (32°) from January 15 to February 21, 1936.

The hottest month on record, at Blair, was July 1936 when the average temperature was 88.4° F. The maximum temperature was 100° or higher on 26 days of the month. A high of 116° was recorded. One night the minimum temperature was 90°.

The average date of the first freezing temperature in fall at the Blair station is approximately October 11. The average date of the last freezing temperature in spring is about April 28. There are rather wide variations from these average dates in individual years.

As shown in table 11, the average annual precipitation is 26.52 inches. Deviations from the average, however, are large as may be seen by comparing the driest year, 15.22 inches (table 12), with the wettest year, 47.49 inches (table 13), a difference of 32.27 inches. The distribution of precipitation during the year is crucial on nonirrigated land. Less precipitation is required for good crop pro-

TABLE 11.—*Temperature and precipitation as recorded at Blair, Washington County, Nebraska*

Month	Temperature							Precipitation	
	Average[1]	Average daily maximum[1]	Average daily minimum[1]	Highest[2]	Year of highest	Lowest[2]	Year of lowest	Average[1]	Average snowfall[2]
	° F.	° F.	° F.	° F.		° F.		Inches	Inches
January	22. 2	32. 1	12. 3	70	1944	−36	1912	. 89	6. 6
February	25. 7	35. 7	15. 7	73	1921	−33	1905	1. 05	6. 5
March	36. 1	46. 1	26. 2	90	1907	−22	1948	1. 70	6. 9
April	51. 3	62. 9	39. 7	98	1898	6	1936	2. 45	1. 4
May	62. 0	73. 4	50. 6	107	1934	22	1908	3. 44	(3)
June	72. 1	82. 7	61. 5	108	[4] 1936	36	1915	4. 34	0
July	77. 3	88. 6	66. 0	116	1936	45	[4] 1915	3. 01	0
August	75. 1	86. 3	64. 0	113	1934	35	1915	3. 31	0
September	66. 2	77. 9	54. 5	106	1939	24	1942	2. 63	0
October	55. 3	67. 6	43. 0	96	1938	8	1925	1. 60	. 4
November	38. 6	49. 2	28. 0	81	1950	−7	1937	1. 26	2. 4
December	27. 8	37. 2	18. 5	72	1939	−25	1917	. 84	5. 3
Annual averages or extremes	50. 8	61. 6	40. 0	116	--------	−36	--------	26. 52	29. 5

[1] Data in column for period 1931–60.
[2] Data in column for period 1898–61.
[3] Trace.
[4] Also in earlier years.

TABLE 12.—*Amount of precipitation during ten driest years of record (1868–1961)*

Month	Years									
	1873	1887	1911	1934	1936	1937	1939	1943	1953	1955
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	1.21	0.33	0.05	0.37	1.57	1.05	0.46	0.10	0.94	0.44
February	.19	.81	1.57	.80	1.29	.15	2.08	.60	.92	.69
March	.45	.52	.94	1.43	.13	2.30	.56	.76	1.55	.85
April	2.69	1.01	2.37	.25	.43	2.27	.51	2.42	3.75	2.29
May	3.43	1.39	3.75	.37	1.19	2.74	1.26	3.46	1.65	1.34
June	4.01	4.94	1.23	2.52	3.06	5.10	2.88	5.40	2.62	5.20
July	3.09	1.17	1.20	1.87	.23	2.76	3.20	4.05	.67	2.32
August	1.14	3.36	1.84	1.08	3.56	.53	2.02	1.74	3.10	2.61
September	.93	2.80	1.17	3.79	2.06	.36	.38	.59	.55	3.45
October	1.49	1.33	1.58	2.36	.38	1.97	.97	.40	.73	.22
November	.06	1.01	.20	2.88	.17	.15	([1])	.61	2.55	.12
December	.78	1.27	3.23	.33	1.15	.11	1.20	.01	1.32	.32
Total	19.47	19.94	19.13	18.05	15.22	19.49	15.52	20.14	20.35	19.85
Amount for April through September	[2] 15.29	[3] 14.67	[4] 11.56	[5] 9.88	[6] 10.53	[7] 13.76	[8] 10.25	[9] 17.66	[10] 12.34	[11] 17.21

[1] Trace.
[2] 79 percent of total for year.
[3] 74 percent of total for year.
[4] 60 percent of total for year.
[5] 55 percent of total for year.
[6] 69 percent of total for year.
[7] 71 percent of total for year.
[8] 66 percent of total for year.
[9] 88 percent of total for year.
[10] 61 percent of total for year.
[11] 87 percent of total for year.

TABLE 13.—*Amount of precipitation during ten wettest years of record (1868–1961)*

Month	Years									
	1869	1875	1881	1884	1896	1902	1903	1909	1915	1951
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
January	0.60	0.48	0.90	0.65	0.40	0.61	0.05	0.57	1.45	0.45
February	1.48	1.31	2.59	1.23	.22	.09	.74	1.89	2.84	2.13
March	.28	2.80	1.35	3.20	1.04	1.25	.74	.31	2.00	3.63
April	2.21	2.50	3.58	2.39	4.42	1.50	2.57	1.78	1.25	5.13
May	4.19	4.31	8.09	1.81	8.35	2.63	9.54	2.38	7.72	7.66
June	8.58	5.70	3.99	3.99	4.74	7.91	3.20	6.81	4.45	3.70
July	8.60	5.62	6.35	7.87	6.69	10.27	6.27	7.97	8.55	3.58
August	6.25	8.45	1.03	5.95	3.25	3.75	11.52	2.38	2.92	6.74
September	9.74	4.39	2.58	8.11	4.20	3.72	3.82	5.58	3.33	2.57
October	.80	.86	5.14	4.52	2.95	2.17	1.34	1.20	.72	2.75
November	1.13	.90	.99	.12	1.90	1.40	1.52	7.38	3.13	.46
December	3.63	2.01	1.06	1.20	.50	2.08	.12	2.39	.49	1.04
Total	47.49	39.33	37.65	41.04	38.66	37.38	41.43	40.64	38.85	39.84
Amount for April through September	[1] 39.57	[2] 30.97	[3] 25.62	[4] 30.12	[5] 31.65	[6] 29.78	[7] 36.92	[8] 26.90	[9] 28.22	[10] 29.38

[1] 83 percent of total for year.
[2] 79 percent of total for year.
[3] 68 percent of total for year.
[4] 73 percent of total for year.
[5] 82 percent of total for year.
[6] 80 percent of total for year.
[7] 89 percent of total for year.
[8] 66 percent of total for year.
[9] 73 percent of total for year.
[10] 74 percent of total for year.

TABLE 14.—*Wettest and driest months, and maximum 24-hour precipitation for each month*

Month	Period 1868–1961: Driest		Period 1868–1961: Wettest		Period 1886–1961	
	Precipitation	Year	Precipitation	Year	Precipitation	Year
	Inches		*Inches*		*Inches*	
January	0.03	1928	2.97	1932	1.20	1947
February	.01	1923	3.32	1908	1.75	1919
March	[1]	1910	4.77	1868	1.85	1959
April	.25	1934	6.99	1944	3.35	1944
May	.37	1934	9.54	1903	3.35	1904
June	.21	1933	10.55	1899	4.52	1942
July	.23	1936	10.27	1902	5.20	1922
August	.33	1913	11.52	1903	5.00	1903
September	.19	1950	11.83	1870	3.48	1938
October	0	1958	5.61	[2] 1928	4.05	1928
November	[1]	[3] 1954	7.38	1909	2.62	1948
December	.01	1943	4.15	1931	2.79	1931

[1] Trace.
[2] Also 1918.
[3] Also 1949 and 1939.

duction during the warm season, April through September, if it is well spaced than if it is ill timed.

The warm-season (April through September) rainfall averages 19.18 inches, 72 percent of the annual amount. During the warm season, the extreme variation has been from a low of 9.88 inches to a high of 39.57 inches (tables 12 and 13), a difference of almost 30 inches. The tabulation of 10 driest years (table 12) shows that 4 of those years were in the 1930's. Only 1 of the 10 wettest years has occurred since 1915 (table 13).

The following list shows, for each month, the probability that precipitation will be less than half of the average. For example, in 17 percent of all years, or nearly 1 year out of 5, April will have less than half of the average precipitation for that month.

Month:	*Percent*
January	35
February	27
March	34
April	17
May	17
June	15
July	18
August	17
September	26
October	23
November	42
December	33

The foregoing probabilities take into account all years since 1867. The average monthly precipitation used in deriving these probabilities is for the period 1931–60 (see table 11). As shown in the foregoing list, precipitation of less than half the average is much more likely to occur in winter months than in summer.

Transportation Facilities

Approximately 690 miles of roads are in Washington County. There are several hard-surfaced State and Federal highways in the county. U.S. Highway No. 30 crosses the Missouri River at Blair and runs west through the towns of Blair, Kennard, and Arlington. U.S. Highway No. 73 runs north from Omaha through Fort Calhoun, Blair, and Herman. State Highway No. 133 runs south of Blair to Omaha, and State Highway No. 91 runs west of Blair across the county. At present two graveled highways are maintained by the State; a hard surface is being constructed on parts of these highways. The rest of the roads are maintained by the county.

The Chicago and North Western Railway crosses the county from east to west and serves Blair, Kennard, and Arlington. A branch of this railroad also enters the county near the town of Washington and leaves the county near Arlington. The Chicago, St. Paul, Minneapolis, and Omaha Railroad, now a part of Chicago and North Western Railway, runs north and south across the county and serves the towns of Fort Calhoun, Blair, and Herman. The Continental, American, and Central Greyhound buslines also serve the county.

The Missouri River has been made navigable by the U.S. Corps of Army Engineers. Transportation by water is possible to all water ports of the world via the Missouri River bargelines.

Omaha, 20 miles south of Blair, provides excellent transportation facilities and markets.

Industries

A mill, built at Fort Calhoun in 1856, was the first industry in Washington County. This historic mill was of great benefit to the early settlers in Washington County and drew trade from as far west as Grand Island, and from the Omaha and Winnebago Indian agencies to the north. The mill was operated by steam, and the big furnace was fueled by wood cut from the surrounding bluffs.

Small industries and manufacturing plants employ many people in Washington County. In Blair, such items as feed wagons, elevators for grain and hay, manure spreaders, power take-off drive units, portable cement mixers, and elevators for road graders are manufactured by several different companies. In Fort Calhoun are manufactured aluminum containers and other aluminum products, crop sprayers, power lawn mowers, refrigeration units for trailers, and fins for bombs and torpedoes. Arlington has a meat-processing plant and a large nursery that handles approximately a million trees a year. There are four rock quarries that supply rock for roads and stabilizing material for use along the Missouri River.

There is some commercial fishing in the Missouri River. Public and private areas for boating, fishing, hunting, and other outdoor recreations are being developed, especially along the Missouri River, which is fairly well stabilized because of upstream dams and channel-control work.

Agriculture

Since earliest settlement, agriculture has been the main interest in Washington County. The first crops consisted of corn, buckwheat, and spring wheat. Potatoes and other vegetables were produced for home use. About 1865 the acreage in spring wheat was greatly increased. Yields of 30 bushels per acre were often obtained. In 1907 winter wheat was introduced and soon replaced spring wheat. Small acreages of buckwheat were grown until 1875. Flax was grown until about 1900. During the late sixties and early seventies, cattle and hogs were an important source of income.

According to the census report of 1879, by far the largest acreage was planted to corn. Wheat was the second largest crop, hay the third, and oats the fourth. A comparatively small acreage was in rye. In addition to these crops, orchard products and small acreages of beans, flax, Irish potatoes, sweet potatoes, tobacco, broomcorn, and sorghum were grown.

In the early years of settlement, the farmers produced only enough crops for local consumption. As a result of increased immigration and the development of markets around 1900, the production of crops and livestock increased. The type of agriculture today is very similar to that of 1900. In the past 30 years, however, sweetclover, red clover, and tame grasses have been added for use as forage and soil-building crops. The drought in the early thirties destroyed many of the bluegrass pastures. These pastures were replaced by bromegrass and alfalfa, which are widely used over the county for temporary pasture.

In 1934, prior to the organization of the Papio Soil Conservation District, a Civilian Conservation Corps camp was established in Blair to do conservation work. This work consisted chiefly of planting trees and building dams for control of erosion. The Corps assisted the soil conservation district for 3 years after it was organized.

As agriculture advanced, there was a noticeable increase in soil erosion. In 1938 the landowners realized the terrific cost of soil erosion and organized the first soil conservation district in Nebraska. This was the Papio Soil Conservation District. The objective was to control erosion, maintain fertility of the soil, and help farmers make good use of the land.

Agricultural data

This section provides data about the total acreage, number, and average size of farms; the acreage of principal crops in stated years; the number of principal livestock on farms in stated years; and the number of livestock and poultry on January 1, 1960. These data were taken from reports of the United States Census of Agriculture.

According to the 1959 Federal census reports 96.5 percent, or 239,042 acres, of Washington County was in farms. Of this, 199,631 acres were in cropland; 11,920 acres in pasture not cropland and not woodland; and 9,751 acres in woodland. There were 17,740 acres in other land (house lots, roads, wasteland, etc.).

The total acreage, number, and average size of farms in stated years are shown in table 15.

Corn is the most important crop in the county. Other important crops are oats, wheat, and hay. The acreage of the principal crops in the county is shown in table 16 for stated years.

Hogs are the principal livestock in Washington County. Cattle and sheep are also important. The numbers of principal livestock in the county are listed in table 17 for stated years, as given in the United States census reports.

TABLE 15.—*Acreage, number, and average size of farms in stated years* [1]

Year	Land in farms	Total farms	Average size of farms
	Acres	*Number*	*Acres*
1930	236, 479	1, 612	146. 7
1940	244, 346	1, 577	154. 9
1950	241, 138	1, 447	166. 6
1959	239, 042	1, 184	201. 9

[1] Based on United States Census of Agriculture.

TABLE 16.—*Acreage of principal crops in stated years* [1]

Crop	1929	1939	1949	1959
	Acres	*Acres*	*Acres*	*Acres*
Corn for all purposes	94, 986	78, 859	99, 535	101, 317
Small grains harvested:				
Oats	36, 865	21, 448	43, 892	26, 591
Wheat	14, 779	18, 363	12, 881	10, 947
Rye	221	2, 132	27	100
Barley	3, 827	6, 419	226	457
Hay crops, total	22, 410	13, 791	16, 433	21, 292
Alfalfa and alfalfa mixtures cut for hay	9, 967	8, 688	12, 546	19, 190
Soybeans grown for all purposes	14	769	2, 139	8, 663
Sorghum for all purposes except sirup	82	9, 999	223	5, 552

[1] Based on reports of the United States Census of Agriculture.

TABLE 17.—*Number of principal livestock on farms in stated years*

Livestock	1930	1940	1950	1959
	Number	*Number*	*Number*	*Number*
Cattle and calves	26, 745	[1] 21, 313	27, 682	45, 573
Milk cows	7, 049	7, 828	6, 784	4, 320
Horses and mules	8, 374	[1] 5, 160	1, 892	426
Hogs and pigs	84, 938	[2] 20, 846	43, 130	66, 460
Sheep and lambs	7, 029	[3] 5, 599	2, 845	14, 990
Chickens	[1] 213, 283	[2] 171, 537	[2] 178, 624	[2] 213, 241

[1] Over 3 months old.
[2] Over 4 months old.
[3] Over 6 months old.

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Glossary

Aggregate (soil structure). Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alkaline soil. Generally, a soil that is alkaline throughout most or all of the parts of it occupied by plant roots, although the term is commonly applied only to a specific layer or horizon of a soil. Precisely, any soil horizon having a pH value greater than 7.0; practically, a soil having a pH above 7.3.

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

Association, soil. A group of soils geographically associated in a characteristic repeating pattern.

Available moisture capacity. The difference between the amount of water in a soil at field capacity and the amount in the same soil at the permanent wilting point. Commonly expressed as inches of water per inch depth of soil.

Bottom lands. The flood plain of a stream, part of which may be flooded at infrequent intervals.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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

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

Loose.—noncoherent; will not hold together in a mass.

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

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

Nonsticky.—When wet, practically no soil material adheres to thumb or finger after release of pressure.

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

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

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

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

Flood plain. Nearly level land, consisting of stream sediment, that borders a stream and is subject to flooding unless protected artificially.

Genesis, soil. The manner in which the soil originated, with special reference to the processes responsible for the development of the solum, or true soil, from the unconsolidated parent material.

Gley soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. The relative position of the several soil horizons in a typical soil profile, and their nomenclature, are as follows:

- A0 Organic debris, partly decomposed or matted.
- A1 A dark-colored horizon having a fairly high content of organic matter mixed with mineral matter.
- A2 A light-colored horizon, often representing the zone of maximum leaching where podzolized; absent in wet, dark-colored soils.
- A3 Transitional to B horizon but more like A than B; sometimes absent.
- B1 Transitional to B horizon but more like B than A; sometimes absent.
- B2 A usually darker colored horizon, which often represents the zone of maximum illuviation where podzolized.
- B3 Transitional to C horizon.
- C Slightly weathered parent material; absent in some soils.
- D Underlying substratum.

The A horizons make up a zone of eluviation, or leached zone. The B horizons make up a zone of illuviation, in which clay and other materials have accumulated. The A and B horizons, taken together, are called the solum, or true soil.

Morphology, soil. The makeup of the soil, including the texture, structure, consistence, color, and other physical, chemical, mineralogical, and biological properties of the various horizons that make up the soil profile.

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

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, value of 6, and a chroma of 4.

Natural drainage. Refers to moisture conditions 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 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.

Imperfectly or somewhat poorly drained soils are wet for significant periods but not all the time, and in podzolic soils commonly have mottlings below 6 to 16 inches, in the lower A horizon and in the B and C horizons.

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.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

pH. A numerical means for designating relatively weak acidity and alkalinity, as in soils and other biological systems. A pH value of 7.0 indicates precise neutrality; a higher value, alkalinity; and a lower value, acidity.

Phase, soil. A subdivision of a soil type, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects management.

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

Runoff. The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the profile.

Shrink-swell potential. The amount that a soil will expand when wet or contract when dry. Indicates kinds of clay in soil.

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.

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

Solum. 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 parent material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are *platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

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

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

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts runoff so that it may soak into the soil or flow slowly to a prepared outlet. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace, diversion. A ridge of earth that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff. The ridge is higher and the channel has more capacity than that of a field terrace.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. (See also Clay, Sand, and Silt.) The basic textural classes, in order of increasing proportions of fine particles are as follows: sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Type, soil. A subdivision of the soil series that is made on the basis of differences in the texture of the surface layer.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Woodland site. A group of soils that produce the same kinds and amounts of forest products and needs similar management.

GUIDE TO MAPPING UNITS AND CAPABILITY UNITS

[See table 1, p. 8, for approximate acreage and proportionate extent of the soils; see table 2, p. 29, for predicted average acre yields of principal crops; and see table 3, p. 33, for woodland sites and species suitable for planting]

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page
	Albaton silt loam	8	IIIw-2	25
Ab	Albaton clay	7	IIIw-1	25
Au	Burchard clay loam, 7 to 12 percent slopes, eroded	9	IIIe-1	24
BdC2	Burchard clay loam, 12 to 18 percent slopes, eroded	9	IVe-1	26
BdD2	Belfore silty clay loam	9	IIe-1	23
Bs	Crofton silt loam, 7 to 12 percent slopes, eroded	11	IIIe-8	25
CfC3	Crofton silt loam, 12 to 18 percent slopes, eroded	11	IVe-8	27
CfD3	Crofton silt loam, 18 to 30 percent slopes	11	VIe-1	27
CfE	Crofton silt loam, 18 to 30 percent slopes, eroded	11	VIe-8	28
CfE3	Carr fine sandy loam	10	IIIw-6	26
Cg	Cass loam	10	I-1	23
Cm	Cass fine sandy loam	10	IIe-3	24
Cs	Gullied land, Judson materials	11	VIIIe-1	28
GL	Haynie silt loam	12	IIw-4	24
He	Judson silt loam, 1 to 3 percent slopes	12	I-1	23
JuA	Judson silt loam, 3 to 7 percent slopes	12	IIe-1	23
JuB	Kennebec silt loam	13	I-1	23
Ke	Lamoure-Colo silty clay loams	13	IIw-4	24
LC	Leshara silt loam	13	IIw-4	24
Le	Leshara soils, clayey substrata	13	IIw-3	24
2Le	Luton and Leshara clays	14	IIIw-1	25
LLu	Luton silty clay loam	14	IIw-4	24
Ls	Luton silt loam, overwash	14	IIw-4	24
Lt	Luton clay	14	IIIw-1	25
Lu	McPaul silt loam	15	IIw-3	24
Mc	Monona-Crofton silt loams, 12 to 18 percent slopes	16	IVe-1	26
MCD	Monona-Crofton silt loams, 12 to 18 percent slopes, eroded	16	IVe-8	27
MCD3	Moody and Marshall soils, 3 to 7 percent slopes	17	IIe-1	23
MMB	Moody and Marshall soils, 3 to 7 percent slopes, eroded	17	IIe-1	23
MMB2	Moody and Marshall soils, 7 to 12 percent slopes	17	IIIe-1	24
MMC	Moody and Marshall soils, 7 to 12 percent slopes, eroded	17	IIIe-1	24
MMC2	Monona silt loam, 0 to 1 percent slopes	15	I-1	23
Mn	Monona silt loam, 1 to 3 percent slopes	15	IIe-1	23
MnA	Monona silt loam, 3 to 7 percent slopes	15	IIe-1	23
MnB	Monona silt loam, 3 to 7 percent slopes, eroded	15	IIe-1	23
MnB2	Monona silt loam, 7 to 12 percent slopes	16	IIIe-1	24
MnC	Monona silt loam, 7 to 12 percent slopes, eroded	16	IIIe-1	24
MnC2	Nora and Crofton soils, 7 to 12 percent slopes, severely eroded	18	IIIe-8	25
NCC3	Nora and Crofton soils, 12 to 18 percent slopes, severely eroded	18	IVe-8	27
NCD3	Nora and Marshall soils, 7 to 12 percent slopes, severely eroded	18	IIIe-8	25
NC3	Nora and Marshall soils, 12 to 18 percent slopes, eroded	18	IVe-1	26
ND2	Nora and Marshall soils, 12 to 18 percent slopes, severely eroded	18	IVe-8	27
ND3	Nora and Moody soils, 12 to 18 percent slopes, eroded	18	IVe-1	26
NMD2	Onawa and Haynie silty clay loams	19	IIw-4	24
OH	Onawa clay	18	IIIw-1	25
Ou	Rauville soils	19	Vw-1	27
Ra	Riverwash	19	VIIIe-1	28
Rw	Spoil banks	21		
S	Sarpy loamy fine sand	20	IIIw-5	26
Sg	Sharpsburg silty clay loam, 0 to 1 percent slopes	20	I-1	23
Sh	Sarpy loam	20	IIw-4	24
Sl	Sharpsburg and Marshall soils, 1 to 3 percent slopes	20	IIe-1	23
SMA	Sharpsburg and Marshall soils, 3 to 7 percent slopes	21	IIe-1	23
SMB	Sharpsburg and Marshall soils, 3 to 7 percent slopes, eroded	21	IIe-1	23
SMB2	Sharpsburg and Marshall soils, 7 to 12 percent slopes	21	IIIe-1	24
SMC	Sharpsburg and Marshall soils, 7 to 12 percent slopes, eroded	21	IIIe-1	24
SMC2	Steinauer soils, 12 to 18 percent slopes, eroded	21	VIe-1	27
StD2	Salix and Volin silt loams	19	I-1	23
Sv				

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