Series 1952, No. 2

Issued January 1959

SOIL SURVEY

Monona County Iowa

OUR SOIL ★ OUR STRENGTH

UNITED STATES DEPARTMENT OF AGRICULTURE

Soil Conservation Service

In cooperation with

IOWA AGRICULTURAL EXPERIMENT STATION

HOW TO USE THE SOIL SURVEY REPORT

THIS SURVEY of Monona County will help you to plan the kind of farming that will protect your soils and provide good yields. It describes the soils, shows their location on a map, and tells what is required for their proper management.

Find Your Farm on the Map

In using this report, start with the maps bound in the back of the report. The first map is an index map that represents the entire county. It is divided into rectangles. Each rectangle has an index number. Determine the quadrangle that covers that part of the county in which your farm is located. Now, find the detailed map that has the same index number as the quadrangle. The map shows towns and villages, roads, streams, and other landmarks. These will help you locate your farm. Each soil is shown by a symbol, such as Aa, and the extent of each area is shown by a boundary line. All areas marked with the same symbol are the same kind of soil wherever they appear on the map. Color patterns also help you pick out the areas of different soils, although each color pattern is used for several soils that resemble each other in some way.

Suppose you have found on your farm an area marked with the symbol Aa. You learn the name of the soil this symbol represents by looking at the map legend. The symbol Aa identifies Albaton clay, 0 to 1 percent slopes.

Learn About the Soils on Your Farm

Albaton clay, 0 to 1 percent slopes, and all the other soils mapped are described in the section, Descriptions of Soils. Soil scientists, as they walked over the fields and through the woodlands, described and mapped the soils. They dug holes and examined surface soils and subsoils; measured slopes with a hand level; noted differences in growth of crops, weeds, brush, or trees; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming.

After they mapped and studied the soils, the scientists talked with farmers and others about the use and management each soil should have and its capabilities for use. They then classified it according to management needs. For example, Albaton clay, 0 to 1 percent slopes, is in class III, subclass IIIw, which consists of soils that can be used for tilled crops but that have moderately severe limitations because of imperfect to poor drainage and poor tilth. You will want to study table 5, which tells you (1) how much corn you can expect to harvest from Albaton clay, 0 to 1 percent slopes, under present practices; (2) estimated average yields per acre of corn, oats, soybeans, and hay under improved management; (3) fertilizer elements most likely to be deficient in this soil; and (4) major practices needed besides fertilizing.

Make a Farm Plan

For the soils on your farm, compare your yields and farm practices with those given in this report. Look at your fields for signs of runoff and erosion. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or for any other farm in the county.

If you find that you need help in farm planning, consult the local representative of the Soil Conservation Service or the county extension director. Members of your State experiment station staff and others familiar with farming in your county will also be glad to help you.

Fieldwork for this soil survey was completed in 1952. Unless otherwise specifically indicated, all statements in this publication refer to conditions in Monona County at that time.

U. S. GOVERNMENT PRINTING OFFICE: 1958

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

Contents

Series 1952, No.2

Issued January 1959

This page intentionally left blank.

SOIL SURVEY OF MONONA COUNTY, IOWA

By E. M. White, J. E. McClelland, C. L. Coultas, and R. C. Prill, Iowa Agricultural Experiment Station and Soil Survey,[1] United States Department of Agriculture, and F. F. Riecken, W. H. Allaway, W. H. Scholtes, and C. E. Hutton, Iowa Agricultural Experiment Station

Correlation by Arvad J. Cline, W. D. Shrader, and Guy D. Smith, United States Department of Agriculture, and F. F. Riecken, Iowa Agricultural Experiment Station

United States Department of Agriculture in cooperation with the Iowa Agricultural Experiment Station

General Nature of the Area

Monona County is largely agricultural. Many of the soils are suitable for a number of different crops. Others can be made suitable if drainage is provided. Some are too eroded or steep to warrant cultivating.

Location and Extent

Monona County is in the extreme western part of Iowa, about halfway between the northern and southern boundaries of the State. The Missouri River forms its western boundary. The county covers approximately 446,080 acres, of which about 423,211 acres is farmland. Onawa, the county seat, is about 40 miles south of Sioux City and about 60 miles north of Council Bluffs (fig. 1).

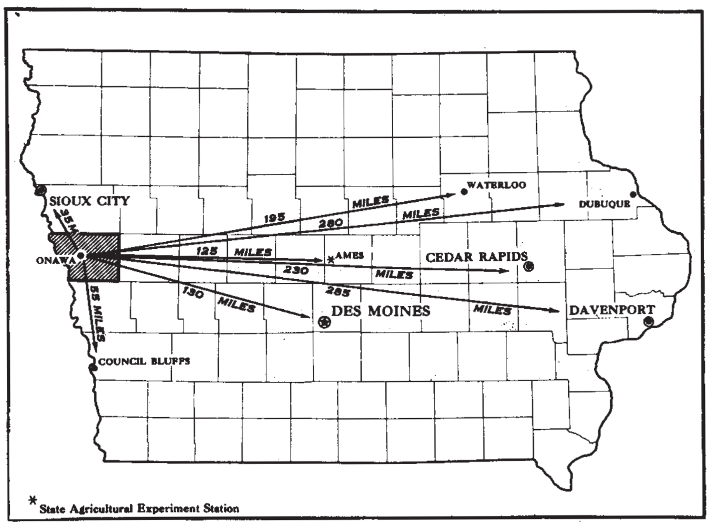


***Figure 1.*—Location of Monona County in Iowa.**

Topography

The county consists of two distinct areas—the broad bottom lands east of the Missouri River and the uplands in the eastern part of the county. The bottom lands are nearly level, and the uplands are rolling to steep. The Little Sioux, Maple, and Soldier Rivers flow through the uplands.

The uplands are between 90 and 300 feet higher than the bottom lands. Onawa has an elevation of 1,055 feet; Blencoe, 1,040 feet; and Whiting, 1,060 feet. All are on bottom lands.

Geology

The geological materials from which the soils of Monona County have formed were deposited (1) by glaciers (glacial till), (2) by wind (loess), and (3) by rivers (alluvium).

Four major glacial ages affected Monona County. The first and second glacial ages were the Nebraskan and the Kansan. During these periods glacial till was deposited. The glacial tills, dominantly of Kansan age, are exposed in a few places in the county. The Steinauer and Shelby soils have formed from these materials. The Kansan till is mostly clay loam in texture. It is moderately compact, or firm, and was calcareous when deposited. It contains pebbles and a few boulders.

Long after the glacial till was deposited, during the fourth, or Wisconsin, glacial age, loess was deposited by the wind on the uplands. Loess mantles all of the uplands and forms a cover that, in places, is as much as 100 feet thick. Except where a few areas of Shelby and Steinauer soils occur, the loessal mantle covers the older geological materials. It is thought to have blown from the bottom lands of the Missouri River between 10,000 and 25,000 years ago. It is high in silt-sized particles and contains about 10 to 15 percent clay, almost no sand, and no gravel. As laid down, the loess was calcareous, friable when moist, and moderately porous.

The alluvium, or river-deposited material, varies in texture and age. The texture varies, both vertically and horizontally, in some areas, within short distances. The major textures of the soils in Monona County that were derived from alluvium are—

Texture	*Soils*
Clay	Albaton, Luton.
Silt over clay	Modale.
Silt	Salix, Haynie.
Clay over silt	Onawa.
Sand	Sarpy.

[1] The Division of Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

Some of the alluvium, especially that from which the soils of association 1 have formed (see fig. 3), was probably deposited within the past few hundred years. In fact recent floods, such as the one in 1952 when the Missouri River overflowed its banks, left sediments. Most of the alluvium from which soils in association 2 were formed is much older than that in association 1.

In parts of association 3, some sediments, mostly silty in texture, have been left with each local flood. In large part these sediments were washed down from the loessal hills. The McPaul soil is forming in some of these materials. Generally, the soils in associations 2 and 3 are fairly high in content of organic matter and have a dark surface layer. In contrast, the alluvial soils in association 1 are low in organic matter and are fairly light colored.

Drainage

The Missouri River is the principal stream that drains Monona County. Although excess water normally runs into this river, at flood stage the process is reversed and the river brings water into the county. The town of Blencoe was inundated in 1952 during one of the most severe floods.

In many years excess water is a problem in association 2 (see fig. 3). Some excess water is caused by heavy local rains, and some areas receive excess water from the Monona-Harrison drainage ditch, the Little Sioux River, and the Maple River.

There were 24 drainage districts in the county in 1940. These served about 240,000 acres, or about half the county. Drainage ditches extended for approximately 247 miles. There are more than 15 miles of drains and 11 miles of levees and dikes. Road ditches are important aids in removing excess water.

In the eastern part of the county, runoff is rapid from the rolling to steep slopes. It is increased when row crops are grown without terracing and contouring. Another serious problem in associations 4 and 5 stems from the development of deep, wide gullies that damage the farms and roads. Some gullies extend for several miles, and in some places they are 50 to more than 100 feet wide.

Climate

Monona County has a humid continental climate with warm summers and moderately cold winters. The normal monthly, seasonal, and annual temperatures, as recorded by the United States Weather Bureau Station at Onawa, are given in table 1.

An average of 159 days a year are without frost. Temperatures vary widely from year to year. Rainfall is also variable. Although the average rainfall for the May-June-

TABLE 1.—*Temperature and precipitation at Onawa Station, Monona County, Iowa*

[Elevation, 1,050 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year (1936)	Total for the wettest year (1903)	Average snowfall
	° F.	*° F.*	*° F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	25. 4	68	−23	0. 90	0. 68	0. 42	6. 2
January	21. 0	69	−25	. 75	1. 52	. 06	7. 5
February	24. 0	66	−27	1. 03	. 94	1. 62	8. 1
Winter	23. 5	69	−27	2. 68	3. 14	2. 10	21. 8
March	37. 2	86	−21	1. 35	. 10	1. 08	7. 3
April	50. 5	91	6	2. 50	1. 47	2. 56	1. 7
May	61. 8	106	23	3. 77	1. 96	14. 76	. 2
Spring	49. 8	106	−21	7. 62	3. 53	18. 40	9. 2
June	70. 9	106	36	4. 45	1. 74	3. 85	(3)
July	76. 2	110	44	3. 71	. 26	7. 21	(3)
August	73. 8	108	38	3. 74	1. 71	11. 62	(3)
Summer	73. 6	110	36	11. 90	3. 71	22. 68	(3)
September	65. 5	104	23	3. 61	3. 99	4. 30	(3)
October	53. 6	97	14	1. 91	. 57	1. 71	. 4
November	38. 1	80	−15	1. 42	. 22	1. 34	2. 9
Fall	52. 4	104	−15	6. 94	4. 78	7. 35	3. 3
Year	49. 8	110	−27	29. 14	15. 16	50. 53	34. 3

[1] Average temperature based on a 53-year record, through 1954; highest temperature based on a 21-year record and lowest temperature based on a 20-year record, through 1952.

[2] Average precipitation based on a 71-year record, through 1955; wettest and driest years based on a 71-year record, in the period 1875–1955; snowfall, based on a 52-year record, through 1952.

[3] Trace.

July period is 11.93 inches, 25.82 inches fell in those months in 1903, the wettest year, and only 3.96 inches during those months in 1936.

Vegetation

Although the temperature was favorable for trees and rainfall was apparently adequate, the native vegetation at the time of settlement was predominantly prairie grasses. The distribution of the trees throughout the State is shown in fig. 2. Where marginal areas were cultivated for a time, some trees have invaded.

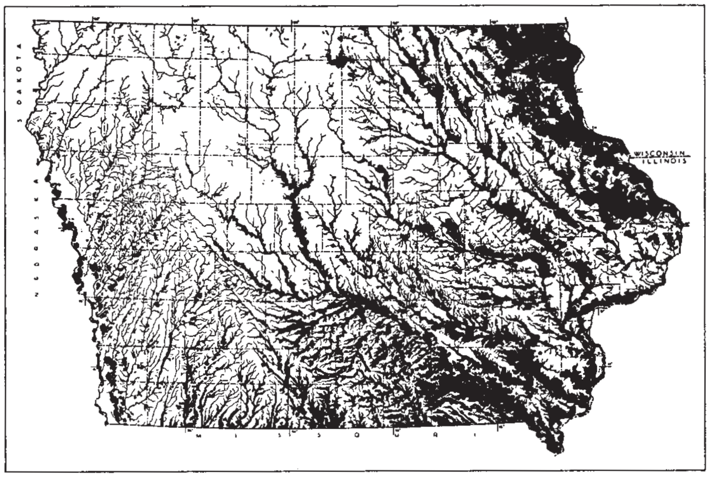


***Figure 2.*—Forest areas in Iowa shown by shading.**

Population

In 1950, the population of Monona County was 16,303, of which 3,498 was urban and 12,805 was rural. There has been a decrease of about 2,000 people in the rural areas since 1940.

Transportation

United States Highway 75 and Iowa State Highway 175 serve Onawa, the county seat, and State Highway 141 crosses the northeastern corner of the county. The Chicago, Milwaukee, St. Paul and Pacific Railroad also crosses this corner. The Chicago and North Western Railway passes through the county from north to south. Onawa is served by this railway.

Agriculture

The agriculture of Monona County is based on the growing of field crops, principally corn, oats, and soybeans. In the following pages, the more outstanding features of the agriculture are pointed out. The statistics used are from reports published by the United States Bureau of the Census.

Types and sizes of farms

In 1954, 3.7 percent of the farms in Monona County were miscellaneous and unclassified. The rest were classified by major source of income as follows:

	Percent
Cash-grain farms	42. 4
Dairy farms	1. 0
Poultry farms	1. 0
Livestock farms other than dairy and poultry	47. 2
General farms	4. 7

Farms have increased in size during the past few years. In 1954, the average-sized farm was 231.9 acres, as compared to 186.9 acres in 1930.

Land use

Monona County covers about 446,080 acres. In 1954, about 94.9 percent of this was land in farms. The following shows how the land in farms was used in 1954:

	Acres
Cropland harvested	271, 154
Cropland used only for pasture	27, 672
Cropland not harvested and not pastured	23, 215
Cropland used only for crops not harvested and not pastured	19, 550
Cropland lying idle	3, 665
Woodland pastured	31, 488
Woodland not pastured	5, 983
Other pasture (not cropland and not woodland)	30, 899
Improved pasture	4, 225
Other land (house lots, roads, wastelands, etc.)	32, 800
Cropland, total	345, 256
Land pastured, total	94, 284
Woodland, total	37, 471

Table 2 lists the soils of Monona County and gives an estimate of the proportionate extent of each soil in various crops and in use for other purposes. Corn has always been the major crop, but the acreage in soybeans has increased appreciably during the past few years. The acreage in wheat varies considerably from year to year but has declined during the past 30 years. During that period, oats and permanent pasture occupied acreages between one-third and one-fourth of the acreage planted to corn. In 1930, the acreage of hay crops from seeded meadows was about one-tenth of the acreage planted to corn. In 1940, it was again about one-tenth of the corn acreage. Table 3 shows the acreage of the principal crops grown in the county in 1929, 1939, 1949, and 1954.

Soybeans and wheat are grown mainly on the bottom lands. Most of the wheat is grown on soils such as the Luton clays that tend to be wet. Corn is grown on Monona silt loam, 7 to 14 percent slopes, and on Monona silt loam, 14 to 22 percent slopes, between 40 and 50 percent of the time, and hay and pasture only one-fifth to one-fourth of the time.

Of the total cropland in 1954, 23,215 acres was not harvested and not pastured. According to the annual census made by the assessor, the percentage of cropland not harvested is highest in the bottom-land townships. Between the years 1939 and 1953, the annual average of the cropland not harvested was 14 percent in Belvedere Township and 19 percent in Ashton Township. In 1951, 47 and 62 percent of the cropland in Belvedere and Ashton, respectively, was not harvested in these bottom-land townships, and in 1944 and 1945, about 45 percent was not harvested. In contrast, nearly all of the crops were harvested in Willow and Cooper Townships, which are in the uplands. Most of the crops not harvested were damaged by excessive wetness caused by floods or by too much rainfall.

TABLE 2.—*Principal soil uses and estimated proportionate extent of soil in each use* [1]

Soil	Corn	Oats	Wheat	Soy-beans	Hay	Pasture	Native timber	Miscel-laneous [2]
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Albaton clay, 0 to 1 percent slopes	50	10	10	10	5	5	5	5
Blencoe silty clay, 0 to 1 percent slopes	55	10	10	15	5	5	[3]	[3]
Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes	50	10	15	15	5	5	[3]	[3]
Castana silt loam, 8 to 14 percent slopes	50	30	[3]	[3]	15	5	[3]	[3]
Castana silt loam, 14 to 22 percent slopes	40	30	[3]	[3]	15	10	[3]	5
Castana silt loam, 22 to 30 percent slopes	20	10	[3]	[3]	5	55	5	5
Colo silty clay loam, 0 to 1 percent slopes	45	10	15	15	5	5	[3]	5
Colo silty clay loam, moderately shallow over silt loam phase, 0 to 1 percent slopes	50	10	10	15	5	5	[3]	5
Colo silty clay loam, calcareous variant, 0 to 1 percent slopes	50	10	10	15	5	5	[3]	5
Cooper silty clay loam, 0 to 1 percent slopes	50	10	10	15	5	5	[3]	[3]
Hamburg silt loam, 30 to 60 percent slopes	0	0	0	0	0	80	5	15
Haynie silt loam, 0 to 1 percent slopes	55	15	5	10	10	5	[3]	[3]
Haynie fine sandy loam, 0 to 1 percent slopes	40	15	5	10	15	10	[3]	5
Haynie loamy fine sand, 0 to 2 percent slopes	25	5	5	5	20	30	5	5
Ida silt loam, 1 to 7 percent slopes	50	20	[3]	[3]	15	15	[3]	[3]
Ida silt loam, 7 to 14 percent slopes	45	20	[3]	[3]	15	20	[3]	[3]
Ida silt loam, 14 to 22 percent slopes	40	20	[3]	[3]	15	20	[3]	[3]
Ida silt loam, 22 to 30 percent slopes	15	5	[3]	[3]	5	60	10	5
Ida silt loam, 30 to 50 percent slopes	5	5	[3]	[3]	5	65	15	5
Kennebec silt loam, 0 to 1 percent slopes	60	15	5	10	5	5	[3]	[3]
Kennebec silt loam, calcareous variant, 0 to 1 percent slopes	60	15	5	10	5	5	[3]	[3]
Luton clay, 0 to 1 percent slopes	30	5	25	15	2	3	[3]	20
Luton clay, overwash phase, 0 to 1 percent slopes	40	10	20	10	5	5	[3]	10
Luton silty clay, moderately shallow over silty clay loam, 0 to 1 percent slopes	40	10	20	15	5	5	[3]	5
McPaul silt loam, 0 to 2 percent slopes	55	15	5	10	5	5	[3]	5
Mixed alluvial land	[3]	[3]	[3]	[3]	[3]	50	30	20
Modale silt loam, 0 to 1 percent slopes	55	15	5	10	10	5	[3]	[3]
Modale sandy loam, 0 to 1 percent slopes	45	15	5	10	10	10	[3]	5
Monona silt loam, 1 to 7 percent slopes	60	25	[3]	[3]	10	5	[3]	[3]
Monona silt loam, 1 to 7 percent slopes, eroded	60	25	[3]	[3]	10	5	[3]	[3]
Monona silt loam, 7 to 14 percent slopes	50	30	[3]	[3]	10	10	[3]	[3]
Monona silt loam, 7 to 14 percent slopes, eroded	50	30	[3]	[3]	10	10	[3]	[3]
Monona silt loam, 14 to 22 percent slopes	40	25	[3]	[3]	15	15	5	[3]
Monona silt loam, 14 to 22 percent slopes, eroded	40	25	[3]	[3]	15	15	5	[3]
Monona silt loam, 22 to 30 percent slopes	15	10	[3]	[3]	10	45	15	5
Monona silt loam, 22 to 30 percent slopes, eroded	15	10	[3]	[3]	10	55	5	5
Monona silt loam, 30 to 40 percent slopes	0	0	[3]	[3]	0	70	20	10
Napa clay, 0 to 1 percent slopes	25	5	40	5	5	10	[3]	5
Napier silt loam, 4 to 10 percent slopes	40	10	[3]	5	5	5	5	30
Onawa silty clay, 0 to 1 percent slopes	50	10	10	10	5	5	5	5
Onawa silty clay loam, 0 to 1 percent slopes	55	10	5	15	10	5	[3]	[3]
Salix silt loam, 0 to 1 percent slopes	65	10	5	10	5	5	[3]	[3]
Salix silty clay loam, 0 to 1 percent slopes	60	10	5	15	5	5	[3]	[3]
Sarpy fine sandy loam, 0 to 4 percent slopes	20	5	5	5	10	20	10	20
Sarpy loamy fine sand, 0 to 4 percent slopes	5	5	5	5	5	20	5	50
Shelby loam, 8 to 14 percent slopes	40	20	[3]	[3]	10	15	5	10
Shelby loam, 14 to 35 percent slopes	20	10	[3]	[3]	15	35	5	15
Steinauer-Castana complex, 8 to 30 percent slopes (less than 15 percent slope)	50	30	[3]	[3]	15	5	[3]	[3]
Steinauer-Castana complex, 8 to 30 percent slopes (greater than 15 percent slope)	25	15	[3]	[3]	15	40	[3]	5
Steinauer loam, 8 to 35 percent slopes	30	15	[3]	[3]	10	30	10	5
Zook silty clay, 0 to 1 percent slopes	40	10	15	10	5	15	[3]	5
Zook silty clay, calcareous variant, 0 to 1 percent slopes	35	10	15	15	10	10	[3]	5

[1] Excluding roads, ditches, farm building sites, towns; estimate is based on normal usage of the soil.

[2] Includes areas not harvested; gullies in some areas.

[3] Little or none of soil in this use.

TABLE 3.—*Acreage of principal crops*

Crop	1929	1939	1949	1954
Corn	165, 610	139, 936	164, 063	127, 090
Oats, threshed	38, 978	27, 388	60, 452	50, 624
Soybeans	56	1, 226	12, 113	57, 065
Wheat, threshed	40, 319	36, 272	26, 883	8, 041
Barley, threshed	5, 899	9, 673	592	205
Popcorn	9	32	177	444
Rye, threshed	244	1, 733	73	77
Flax, threshed	829	40	(1)	(1)
Field seed crops	1, 395	2, 477	579	814
Hay	27, 902	23, 531	23, 581	29, 623
Pasture	91, 576	61, 455	87, 908	90, 059

[1] Not reported.

Livestock and livestock products

Livestock raising is an important industry in Monona County. The number of domestic animals on farms in 1954 is shown in the following list:

Chickens (4 months old and over)	210, 775
Hogs and pigs	104, 166
Cattle and calves	46, 814
Sheep and lambs	7, 155
Horses and mules	1, 093

In 1954, 2,713,892 pounds of whole milk was sold, and 630,702 pounds of butterfat. Among other livestock products sold was 1,070,213 dozen eggs.

How a Soil Survey Is Made

The scientist who makes a soil survey examines soils in the field, classifies the soils in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map.

FIELD STUDY.—The soil surveyor examines vertical 3- to 5-foot sections in pits, recent roadbanks or gullies, and bores or digs many holes to see what the soils are like. The holes are not spaced in a regular pattern but are located according to the lay of the land. Usually they are not more than a quarter of a mile apart, and sometimes they are much closer. In most soils each boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. Each layer is studied to see how it differs from others in the profile and to learn the things about the soil that influence its capacity to support plant growth.

Color is usually related to the amount of organic matter. The darker the surface soil, as a rule, the more organic matter it contains. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

Texture, or the content of sand, silt, and clay, is determined by the way the soil feels when rubbed between the fingers, and is later checked by laboratory analysis. Texture determines how well the soil retains moisture, plant nutrients, and fertilizer, and whether it is easy or difficult to cultivate.

Structure, which is the way the individual soil particles are arranged in aggregates and the amount of pore space between aggregates, gives us clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture. The aggregates may have prismatic, columnar, blocky, platy, or granular structure.

Consistence, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

Other characteristics observed in the course of the field study and considered in classifying the soil include the following: The depth of the soil over bedrock or compact layers; the presence of gravel or stones in amounts that will interfere with cultivation; the steepness and pattern of slopes; the degree of erosion; the nature of the underlying parent material from which the soil has developed; and the acidity or alkalinity of the soil as measured by chemical tests.

CLASSIFICATION.—On the basis of the characteristics observed by the survey team or determined by laboratory tests, soils are classified by series, types, and phases.

As an example of classification, consider how the Haynie series of Monona County is separated into types and phases:

Series	*Type*	*Phase*
Haynie	Fine sandy loam	0 to 1 percent slopes.
	Loamy fine sand	0 to 2 percent slopes.
	Silt loam	0 to 1 percent slopes.

Soil series.—Soils similar in kind, thickness, and arrangement of layers are normally designated as a soil series. In a given area, however, a soil series may be represented by only one soil. Each series is named for the place near which it was first mapped. For example, the Monona soils were first mapped in Monona County.

Soil type.—Within a soil series, there may be one or more soil types. The soil types are determined by the texture of the surface layer.

Soil phase.—Soil types are divided into soil phases because of differences other than those of kind, thickness, and arrangement of layers. Variations in slope, frequency of rock outcrops, degree of erosion, depth of soil over the substratum, or natural drainage are examples of characteristics that suggest dividing a soil type into phases.

The soil phase, or the soil type, if it has not been subdivided, is the mapping unit on the soil map. It is the unit that has the narrowest range of characteristics. Use and management practices, therefore, can be specified more easily than for soil series or yet broader groups that contain more variation.

Soil variant.—A taxonomic unit closely related to another taxonomic unit, such as a soil series, but having at least one differentiating characteristic at the series level is a soil variant. It takes its name from the series as modified by the principal distinguishing feature. Variants are really separate soil series but of too small known extent to justify establishing a new series. Colo silty clay loam, calcareous variant, 0 to 1 percent slopes, is an example of a soil variant mapped in this county.

Soil complex.—When two or more soils are so intricately associated in small areas that it is not feasible to show them separately on the soil map, they are mapped together and called a soil complex. The Steinauer-Castana complex, 8 to 30 percent slopes, is an example of a soil complex mapped in this county.

Soil Associations

The map of soil associations (fig. 3) shows the general patterns of the soils in Monona County. This map is helpful in studying the soils of the county in general, or it can be an aid to broad program planning. Each association contains several different soils, arranged in a characteristic pattern. In most places the pattern is related to the nature of the soil materials and the shape of the land surface.

The five associations in Monona County are briefly discussed in the following pages. Figure 4, a schematic diagram, shows the relative position on the landscape of some of the dominant soils and the broad range of slope on which each occurs. It also shows the typical profiles of six of the principal soils.

1. Recent Alluvial Light-Colored Soils of the Missouri River Flood Plain: Albaton, Onawa, Haynie

In association 1, as shown on the soil association map, are soils of the Missouri River flood plain. The major soils are the Albaton, Onawa, and Haynie. Less extensive are the McPaul, Modale, and Sarpy soils, and Mixed alluvial land. All were derived from sediments deposited by the river. Many areas occasionally receive fresh sediments when the river overflows. Because the river sediments vary considerably, the texture of the soils varies.

This association is all nearly level to gently sloping. Some parts have so little slope that surface runoff is slow. Consequently, these soils may be too wet, especially if they have a fine texture so that moisture moves through

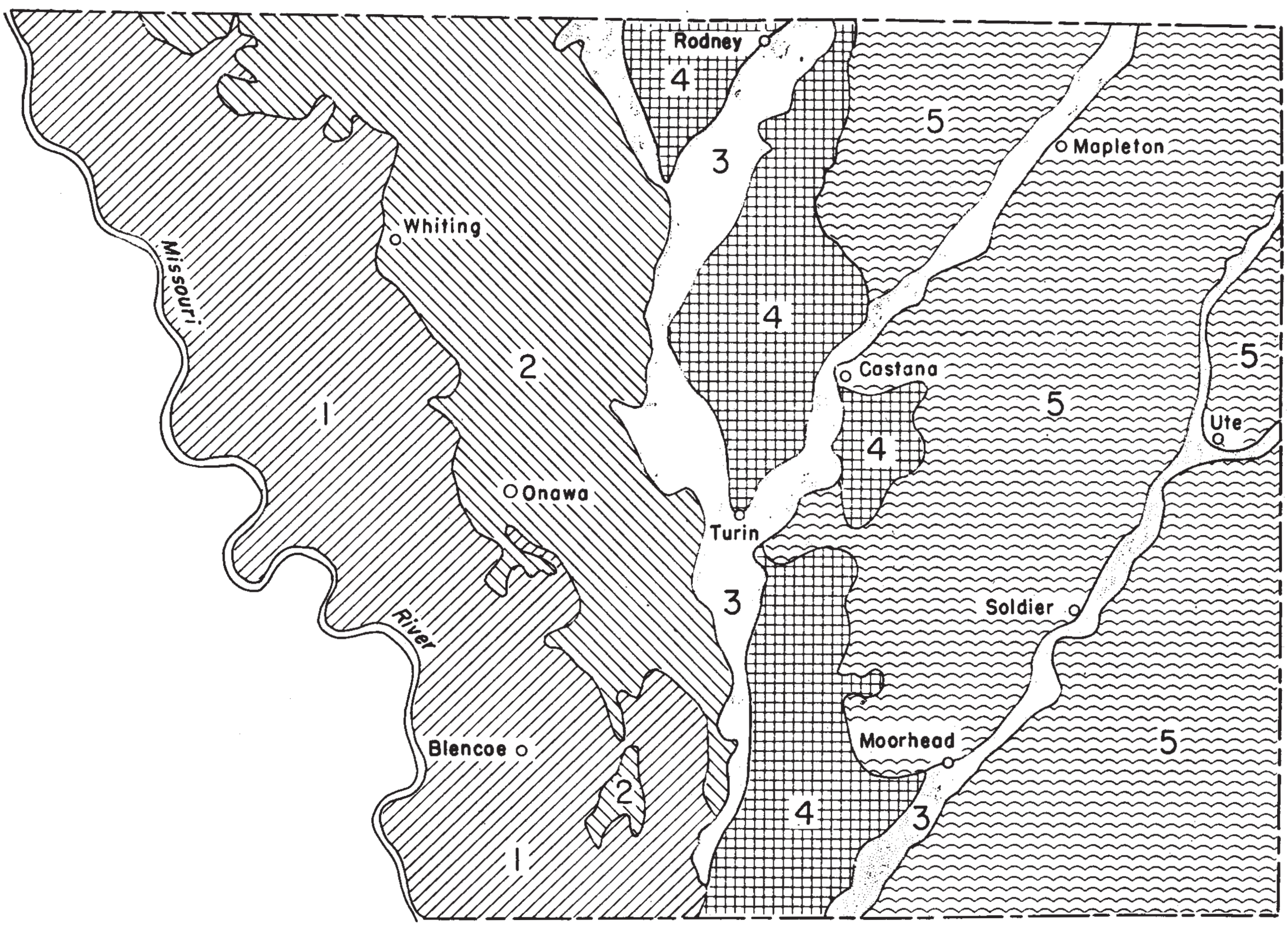


Figure 3.—**Soil associations of Monona County, Iowa:**

1. **Recent alluvial light-colored soils of the Missouri River flood plain: Albaton, Onawa, Haynie.**
2. **Principally dark colored soils of the Missouri River flood plain: Luton, Salix, Blencoe, and McPaul.**
3. **Soils of the flood plains of tributary streams: Kennebec, Zook, McPaul.**
4. **Mostly steep soils formed from loess and local alluvium: Hamburg, Ida, Castana, Napier.**
5. **Gently sloping to steep soils formed from loess and local alluvium: Monona, Ida, Napier.**

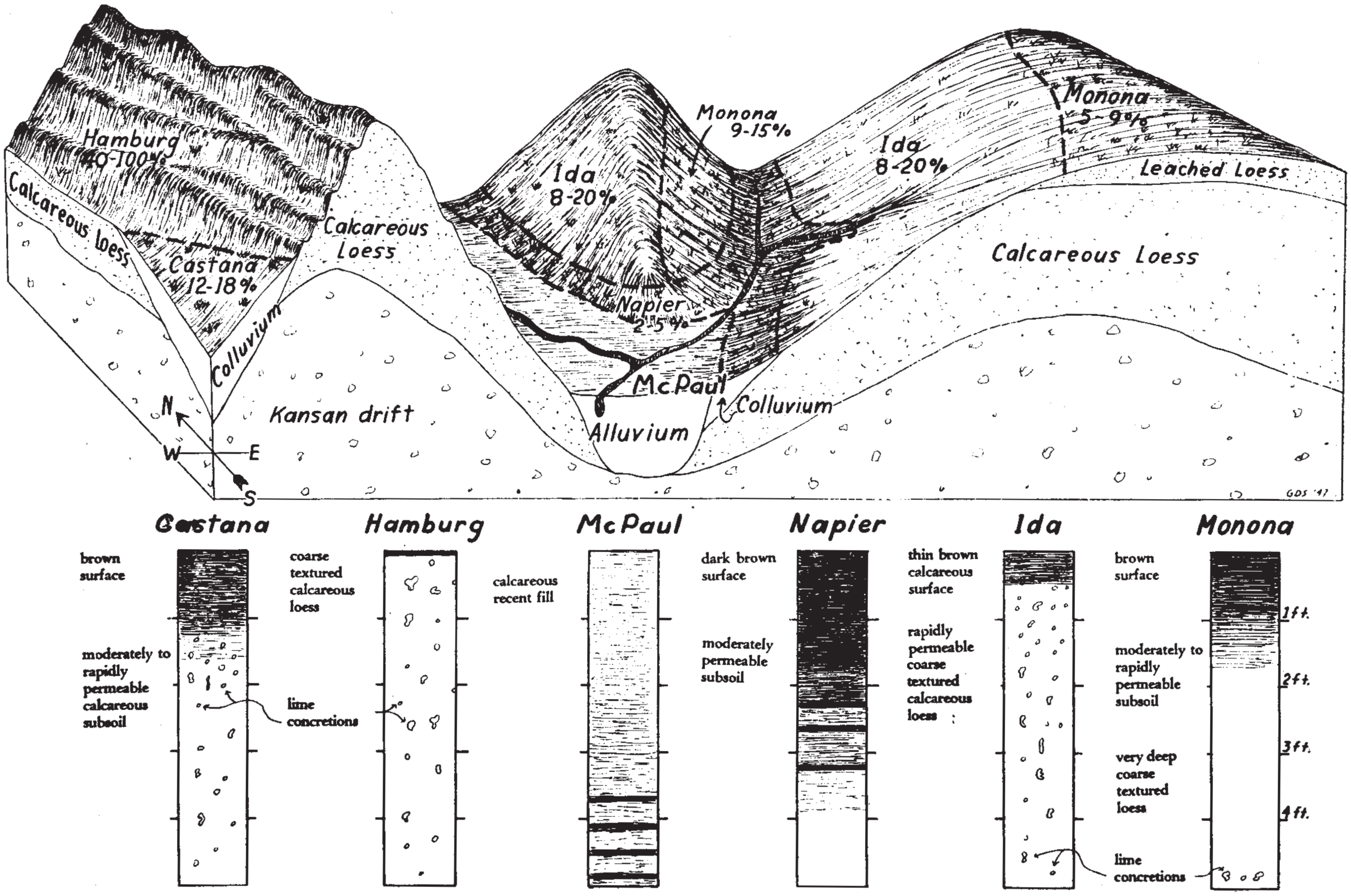


Figure 4.—Schematic diagram of some of the dominant soils in Monona County.

them slowly. Wind erosion is a hazard on the Haynie and Sarpy soils.

Corn and soybeans are grown on many of the soils. Mixed alluvial land is used for cropping to some extent, but most of the association is covered by trees, brush, and swamp plants. Because of the risk of wind erosion, the sandier areas of Sarpy soils are suited only to permanent pasture or trees.

2. Principally Dark Colored Soils of the Missouri River Flood Plain: Luton, Salix, Blencoe, and McPaul

Association 2 is comprised of soils of the Missouri River flood plain. The Luton, Salix, Blencoe, and McPaul are the most extensive soils in the association, but Colo, Cooper, and Napa soils also occur. The soils occupy nearly level areas or slight depressions, mainly in the eastern half of the Missouri River bottom lands. The Luton, Napa, and Blencoe soils are fine textured; the Colo, Cooper, and some of the Salix soils are moderately fine textured; and the McPaul and the rest of the Salix soils are medium textured.

The Luton soils are in the central part of the Missouri River bottoms, and the Salix soils are in the middle and eastern parts. The McPaul soil occurs along streams and ditches that flow in or from the uplands. The Blencoe soils occupy areas next to the Salix and Luton soils. The Colo soils occur mainly on the flood plain at the place where the Little Sioux and Maple Rivers join the main bottom land of the Missouri River. Most of the Napa soil occurs within larger areas of Luton soils.

Drainage is a problem on much of this association. Where drainage has been improved, corn, soybeans, wheat, and oats are commonly grown.

3. Soils of the Flood Plains of Tributary Streams: Kennebec, Zook, McPaul

Association 3 extends along the eastern edge of the Missouri River bottom lands and into the uplands along the Maple, Soldier, and Little Sioux Rivers. The principal soils in this association are the Kennebec, Zook, and McPaul. Colo soils occur to a lesser extent, and there are a few isolated areas of Luton and Napa soils. The Zook and Colo soils occur most extensively along the

446458—58——2

border between associations 2 and 3. All of the soils have formed from silty or clayey alluvial sediments.

Most of association 3 is subject to flooding, and the soils are often wet. When not flooded, they are fairly to highly productive. Corn, soybeans, and oats are commonly grown on these soils. Winter wheat is grown on some of the wetter soils, because it can be seeded in the fall when the soil is usually dry.

4. Mostly Steep Soils Formed From Loess and Local Alluvium: Hamburg, Ida, Castana, Napier

The soils of association 4 occur mainly on steep slopes. They have formed in loess or local alluvium. The Hamburg, Ida, Castana, and Napier soils are the most extensive soils in the association. A small proportion is occupied by Monona, Shelby, and Steinauer soils. The Hamburg, Ida, and Monona soils have formed on windblown silts.

This association occupies about one-fourth to one-third of the uplands. Elevations range from 1,100 to 1,300 feet. The steepest land in the county is in this association.

The Hamburg soil is marked by "catsteps" on slopes of 40 to 100 percent, but slopes of 30 to 60 percent are more common. The Ida soils occur on slopes of 1 to 50 percent, but slopes of 10 to 20 percent predominate. The Castana soils have formed on steeper colluvial slopes (12 to 18 percent) below Hamburg or Ida soils. The Napier soil occurs on colluvial slopes of 4 to 10 percent below Castana, Ida, or Monona soils. The Monona soils occur on broader ridges on north- or east-facing slopes. The Shelby and Steinauer soils have formed from glacial till. They occur on slopes of 8 to 35 percent and are below Monona and Ida soils or Castana and Hamburg soils.

The Hamburg soil and most Ida and Monona soils on slopes steeper than 18 percent are used for grazing. The other soils in association 4 are suited to crops commonly grown in the county. Except for the Napier, all of the soils in association 4 are subject to severe sheet erosion. The Napier soil, and, to a somewhat lesser extent, all of the other soils, are subject to severe gully erosion.

5. Gently Sloping to Steep Soils Formed From Loess and Local Alluvium: Monona, Ida, Napier

Association 5 is the largest of the soil associations. It covers about a third of the county. The Monona, Ida, and Napier soils are the dominant soils, but small areas of Castana, Shelby, and Steinauer soils occur, and McPaul and Kennebec soils are on bottom lands along the larger streams. This association is in the eastern part of the uplands. Slopes are rolling to steep, and the elevation is about the same as in association 4. The association is dissected by the Maple and Soldier Rivers and their tributaries.

As in association 4, many of the soils are eroded. Where terracing and contouring cannot be used effectively, the soils are suitable only for permanent pasture.

Descriptions of Soils

This section contains detailed descriptions of the soils mapped in Monona County. After the name of each soil is the letter symbol that identifies that particular soil on the map placed in the back of this report.

In the section, Capability of Monona County Soils, the capability classification of each soil is given. The approximate acreage and proportionate extent of each mapping unit are shown in table 4.

Albaton Soils

The Albaton soils, represented in Monona County by Albaton clay, 0 to 1 percent slopes, occupy level areas or depressions. They occur within a few miles of the Missouri River. The soils are forming from sediments deposited by the river. They are occasionally flooded, especially the lower areas that once were old bayous. Each major overflow adds sediments, and as a result the soils have not developed clearly defined horizons. They are classified as Alluvial soils.

Albaton clay, 0 to 1 percent slopes (Aa).—This nearly level soil is occasionally flooded by the Missouri River. It has slow surface drainage and is excessively wet during rainy seasons. It generally occurs in association with the Onawa and Haynie soils. In most places this soil is clay throughout the profile. The Onawa soils, in contrast, generally have silty materials at depths below 20 to 30 inches. Except for this difference, this soil is similar to the Onawa soils. Because river deposits are variable, the areas of Albaton and Onawa soils are so intermingled in some places that it is difficult to separate them. Therefore, some minor areas of Onawa soils occur within this soil.

Typical profile: [2]

A 0 to 6 inches, very dark grayish-brown (10YR 3/2) medium clay (about 45 to 50 percent clay); very hard when dry, firm when moist; very fine blocky; neutral.

C_g 6 to 50 inches, dark grayish-brown (10YR 4/2) medium clay (about 50 percent clay); a few faint yellowish-brown mottles, more distinct and prominent in lower part of horizon; very hard when dry, and firm to very firm when moist; fine blocky structure; slightly calcareous; somewhat darker color at depths between 27 and 34 inches indicates material was once the surface layer of an older buried soil.

VARIATIONS.—The texture of the surface layer ranges from medium clay to light silty clay. In some places thin layers of silt occur in the lower part of the profile; generally these are in areas that lie next to Onawa soils. The surface soil ranges from neutral to slightly calcareous.

Use and management.—Management of this soil will always be difficult. In many places drainage must be improved and overflows prevented if the soil is to be used for crops. Ditches and drains should be provided, if feasible, and dikes should be erected to protect some areas. Because of the clay texture, permeability is very slow. Therefore, tiling is not generally practical.

The clay or silty clay surface layer causes this soil to become cloddy if tilled too wet. In the spring the soil is often so wet that planting is delayed. Then a specific

[2] Unless otherwise stated, color and structure are described for a moist soil. Symbols express Munsell color notations.

rotation may be difficult to follow. In wet seasons some farmers substitute soybeans for corn in the rotation or grow wheat.

TABLE 4.—*Acreage and proportionate extent of the soils mapped*

Soil	Acres	Percent
Albaton clay, 0 to 1 percent slopes	32, 033	7. 2
Blencoe silty clay, 0 to 1 percent slopes	7, 939	1. 8
Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes	3, 114	. 7
Castana silt loam, 8 to 14 percent slopes	1, 574	. 4
Castana silt loam, 14 to 22 percent slopes	24, 698	5. 5
Castana silt loam, 22 to 30 percent slopes	93	(1)
Colo silty clay loam, 0 to 1 percent slopes	5, 382	1. 2
Colo silty clay loam, moderately shallow over silt loam, 0 to 1 percent slopes	2, 117	. 5
Colo silty clay loam, calcareous variant, 0 to 1 percent slopes	31	(1)
Cooper silty clay loam, 0 to 1 percent slopes	1, 421	. 3
Hamburg silt loam, 30 to 60 percent slopes	17, 419	3. 9
Haynie fine sandy loam, 0 to 1 percent slopes	2, 402	. 5
Haynie loamy fine sand, 0 to 2 percent slopes	68	(1)
Haynie silt loam, 0 to 1 percent slopes	7, 406	1. 7
Ida silt loam, 1 to 7 percent slopes	165	(1)
Ida silt loam, 7 to 14 percent slopes	7, 879	1. 8
Ida silt loam, 14 to 22 percent slopes	32, 385	7. 3
Ida silt loam, 22 to 30 percent slopes	14, 718	3. 3
Ida silt loam, 30 to 50 percent slopes	6, 839	1. 5
Kennebec silt loam, 0 to 1 percent slopes	10, 280	2. 3
Kennebec silt loam, calcareous variant, 0 to 1 percent slopes	93	(1)
Luton clay, 0 to 1 percent slopes	52, 499	11. 8
Luton clay, overwash phase, 0 to 1 percent slopes	13, 582	3. 0
Luton silty clay, moderately shallow over silty clay loam, 0 to 1 percent slopes	3, 638	. 8
McPaul silt loam, 0 to 2 percent slopes	13, 014	2. 9
Mixed alluvial land	8, 294	1. 9
Modale silt loam, 0 to 1 percent slopes	3, 035	. 7
Modale sandy loam, 0 to 1 percent slopes	569	. 1
Monona silt loam, 1 to 7 percent slopes	16, 947	3. 8
Monona silt loam, 1 to 7 percent slopes, eroded	759	. 2
Monona silt loam, 7 to 14 percent slopes	23, 802	5. 3
Monona silt loam, 7 to 14 percent slopes, eroded	6, 586	1. 5
Monona silt loam, 14 to 22 percent slopes	9, 999	2. 2
Monona silt loam, 14 to 22 percent slopes, eroded	4, 700	1. 1
Monona silt loam, 22 to 30 percent slopes	1, 244	. 3
Monona silt loam, 22 to 30 percent slopes, eroded	368	. 1
Monona silt loam, 30 to 40 percent slopes	133	(1)
Napa clay, 0 to 1 percent slopes	420	. 1
Napier silt loam, 4 to 10 percent slopes	46, 880	10. 5
Onawa silty clay, 0 to 1 percent slopes	23, 985	5. 4
Onawa silty clay loam, 0 to 1 percent slopes	2, 989	. 7
Salix silty clay loam, 0 to 1 percent slopes	8, 348	1. 9
Salix silt loam, 0 to 1 percent slopes	5, 095	1. 1
Sarpy fine sandy loam, 0 to 4 percent slopes	2, 427	. 5
Sarpy loamy fine sand, 0 to 4 percent slopes	1, 030	. 2
Shelby loam, 8 to 14 percent slopes	52	(1)
Shelby loam, 14 to 35 percent slopes	88	(1)
Steinauer loam, 8 to 35 percent slopes	219	. 1
Steinauer-Castana complex, 8 to 30 percent slopes	822	. 2
Zook silty clay, 0 to 1 percent slopes	3, 104	. 7
Zook silty clay, calcareous variant, 0 to 1 percent slopes	202	(1)
Water	13, 194	3. 0
Total	446, 080	100. 0

[1] Less than 0.1 percent.

If the surface layer becomes cloddy, careful tillage and cropping is necessary. Some farmers plow in the fall so that winter freezing will break up the larger clods. Crop residues and manure returned to the soil over a period of 1 or 2 years will improve the structure of the soil.

This soil is low in organic matter and available nitrogen. It contains moderate amounts of available phosphorus and potassium. Lime is generally not needed. This soil is in capability class III, subclass IIIw.

Blencoe Soils

The Blencoe soils occur in the eastern half of the bottom lands along the Missouri River. Most of the soils occupy nearly level areas or slight depressions next to Salix and Luton soils. Like the other soils of the bottom lands, these soils have formed from alluvial materials, but flooding is only a slight hazard. The surface layer is medium to high in organic matter. The soil is 40 to 50 percent clay. The color of the subsoil ranges from very dark grayish brown to dark yellowish brown. The soils are classed as Brunizems, but they grade to Humic Gley (Wiesenboden).

Blencoe silty clay, 0 to 1 percent slopes (Ba).—This nearly level soil has somewhat slow surface drainage and a slight tendency to wetness.

Typical profile:

A_1 0 to 10 inches, black (10YR 2/1) silty clay (about 45 percent clay); hard when dry, firm when moist; fine granular structure; slightly acid to neutral.

A_3 10 to 16 inches, very dark brown (10YR 2/2) silty clay; hard when dry, firm when moist; fine granular to fine blocky structure; slightly acid to neutral.

B_1 16 to 20 inches, very dark grayish-brown (10YR 3/2) and dark yellowish-brown (10YR 4/4) light silty clay, the colors mixed to give a mottled appearance; hard when dry, firm when moist; fine granular structure; neutral to slightly calcareous.

D 20 to 50 inches, dark grayish-brown (10YR 4/2) and olive-brown (2.5Y 4/4) silt loam; soft when dry, friable when moist; neutral to calcareous.

VARIATIONS.—In texture the surface layer ranges from a light silty clay to a medium silty clay (from 40 to 50 percent clay). Because most of this soil lies between areas of Salix soils and areas of Luton soils, its subsoil in some places is yellowish brown like that of the Salix soils. In other places it is olive gray like that of the Luton soils.

Use and management.—Some of this soil needs surface drainage. Ditches will help to remove excess surface water, but some areas will need additional drainage. The lower part of the profile consists of silt loam and has moderate permeability. Therefore, if suitable outlets are available, tiling may prove beneficial. Because of the fine texture of the surface layer, the soil should not be tilled when it is wet. Some farmers prefer to fall-plow so that the freezing and thawing will break down the larger clods.

The soil has a moderately large supply of organic matter and a medium supply of phosphorus and potassium. Soil tests should be made to determine the need for amendments. Crop residues and manure should be returned to the soil as an aid to maintaining a granular seedbed. Using grass and legume meadow in the crop rotation will also help. A fairly wide choice of crop rotations is available for this soil, provided a granular seedbed can be maintained. This soil is in capability class II, subclass IIw.

Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes (Bb).—This soil occupies level areas or slight depressions where slopes are less than 1 percent.

Typical profile:

A_1 0 to 9 inches, black (10YR 2/1) light silty clay; hard when dry, firm when moist; fine granular structure; neutral to slightly acid.

A_{12} 9 to 14 inches, very dark brown (10YR 2/2) light silty clay; hard when dry, firm when moist; fine granular structure; neutral to slightly acid.

B_1 14 to 18 inches, very dark grayish-brown and dark yellowish-brown (10YR 3/2 and 4/4) light silty clay; hard when dry, and firm when moist; medium granular to fine subangular blocky structure; neutral to slightly acid.

C–D 18 to 28 inches, very dark gray and dark yellowish-brown (10YR 3/1 and 4/4) light silty clay, interlayered with silt loam and silty clay loam; a few distinct yellowish-brown mottles; moderately hard when dry, slightly firm to firm when moist; structure granular in silt loam part and fine blocky in silty clay part; neutral to calcareous.

D 28 to 40 inches, very dark grayish-brown (10YR 3/2) and olive-brown (2.5Y 4/4) silty clay; a few faint yellowish-brown mottles; hard when dry, firm to very firm when moist; fine blocky structure; neutral to slightly calcareous; layer may be the surface layer of an older, but now buried, soil.

VARIATIONS.—In some places, where this soil lies next to areas of Luton clay, overwash phase, 0 to 1 percent slopes, the surface layer is grayish brown instead of black. The depth to the silty clay D horizon varies. In places where the silt loam or silty clay loam layer is thick, the silty clay layer is at depths of as much as 36 to 40 inches.

Use and management.—Where feasible, drainage should be improved by ditches. If tiles are used, they should be placed above the silty clay layer of the lower part of the subsoil. The silty clay texture of the subsoil causes permeability to be slow to very slow, so that tile must be spaced closely if drainage is to be improved by tiling. Because the surface layer is fine textured, and this soil tends to be wet, cultivating and planting are often difficult. The soil becomes cloddy if tilled too wet. Some farmers fall-plow so that winter freezing and thawing will break up the larger clods. Some of the granular structure of the surface layer can be restored by growing a grass-legume sod.

The choice of crops and rotations will often be limited on this soil by wetness. Therefore, it may not be feasible to follow a fixed rotation, and if tilth does not become a serious problem, it may not become necessary. Ordinarily, corn or soybeans will be the best crops in seasons of normal rainfall, but some farmers plant winter wheat on the wetter areas.

Although this soil is moderately fertile, soil tests are advisable to determine the need for plant nutrients and the choice of fertilizers for the various crops. This soil is in capability class II, subclass IIw.

Castana Soils

The Castana soils occur in the uplands where they are associated with the Hamburg, Ida, and Napier soils. They are forming from calcareous silt or silt loam washed or slumped from the Hamburg and Ida soils. In general the Castana soils all have the same texture; they are placed in different mapping units because of differences in slope. Their surface layer contains an estimated 22 to 25 percent clay, less than 10 percent sand, and considerable coarse silt. Their substratum contains an estimated 12 to 18 percent clay, less than 10 percent sand, and considerable coarse silt.

The Castana soils grade toward the Napier soil that generally occurs on less steep slopes. Separation of the Castana and Napier soils was somewhat arbitrary, but the degree of slope was ordinarily used as a guide. Although the Castana soils do not have sharply differentiated layers, they are classed as Brunizems. They grade toward the Regosol great soil group.

Prairie grasses were the original vegetation on these soils. Shrubs and small trees now grow on many of the areas used for pasture.

Castana silt loam, 8 to 14 percent slopes (Ca).—This medium-textured soil is forming from materials washed or slumped from higher lying areas of Hamburg and Ida soils.

Typical profile:

A_1 0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam; soft when dry, friable when moist; crumb structure; slightly calcareous.

A_{12} 6 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam; soft when dry, friable when moist; crumb structure; slightly calcareous.

A_3 12 to 21 inches, very dark grayish-brown or brown (10YR 3/2 or 5/3) silt loam; soft when dry, friable when moist; crumb to fine granular structure; slightly calcareous; more or less transitional to both the A and C horizons.

C 21 to 38 inches, brown (10YR 5/3) silt loam tending to silt; soft when dry, friable when moist; crumb to fine granular structure; highly calcareous.

VARIATIONS.—The total thickness of the dark-colored A layers varies in these soils. In the areas that border the Hamburg and Ida soils, the total thickness of these layers is as much as 10 inches; in areas that border the Napier soil, their total thickness is about 25 inches. In most places the thickness of the A layers is about 20 inches. Depth to the strongly calcareous layer varies more or less with the total thickness of the A layers. Although the Castana soils in some places are not calcareous above 25 inches, in most places they are slightly calcareous within 10 to 20 inches of the surface.

Use and management.—Because the slopes are moderately steep, sheet erosion is a hazard on Castana silt loam, 8 to 14 percent slopes. In addition, runoff from higher lying areas often causes gullies. This soil is moderately permeable. Therefore, it is suited to such practices as contour tillage and use of level terraces. These practices are difficult to apply, however, because the soil receives runoff from the higher lying Hamburg and Ida soils, is gullied, and in some areas has steep slopes. Generally, erosion must be controlled on the adjacent higher lying soils before erosion can be controlled satisfactorily on this soil. If the development of gullies is to be checked, however, the loss of soil material should be limited to about 5 tons per acre each year.

All tillage should be on the contour. For crops such as corn, the practice of listing on the contour will help to control erosion. Contour tillage should be supplemented by using terraces wherever feasible. As terrace outlets are likely to be a problem because of the steep slopes, level terraces should be constructed. A representative of the Soil Conservation Service should be consulted for technical assistance.

Terraces or diversion ditches may be needed to help control runoff from higher areas. Grassed waterways should be established in natural waterways and in other places where water from runoff concentrates.

If contour tillage and terraces are impractical, it will be necessary to use a rotation that includes a considerable amount of grass-legume meadow. If terraces are not used, the rotation should consist of corn 1 year; oats 1 year; and meadow 3 years. If contouring and terracing are used, corn may be grown for 2 years, oats 1 year, and meadow 1 year. Generally, the steeper the slope the less frequently corn should be planted. By using a suitable rotation and contouring and terracing, corn can be grown more frequently without loss of soil and water.

This soil is moderately fertile. Normally, it has a high content of available potassium. The supply of available phosphorus is likely to be variable, depending on past management, so soil tests should be made to determine the need for phosphorus. The soil has a moderate supply of nitrogen, so response of such crops as corn to nitrogen fertilizers would not likely be so great as in the eroded Ida and Monona soils. Nitrogen, however, must be supplied either in fertilizers or by legume meadows if grain yields are to be maintained. Generally lime is not needed. This soil is in capability class III, subclass IIIe.

Castana silt loam, 14 to 22 percent slopes (Cb).—Except for slope, this soil is similar to Castana silt loam, 8 to 14 percent slopes.

Use and management.—In general, this soil is used and managed the same as Castana silt loam, 8 to 14 percent slopes, except that the steeper slopes may not be suited to terraces. The rotations used, however, should include more meadow or permanent pasture. If contouring and terracing are not used, this soil should be kept in meadow or permanent pasture. If contouring or terracing are practiced, the soil may be used for corn 1 year, oats 1 year, and meadow 2 years. This soil is in capability class IV, subclass IVe.

Castana silt loam, 22 to 30 percent slopes (Cc).—Except for having steeper slopes, this soil is similar to Castana silt loam, 8 to 14 percent slopes.

Use and management.—This soil is used and managed in much the same way as Castana silt loam, 8 to 14 percent slopes, except that slopes greater than 15 to 20 percent are not suited to terraces. The soil can be used for meadow or permanent pasture. It is in capability class VI, subclass VIe.

Colo Soils

The Colo soils occur mainly on nearly level flood plains in the eastern part of association 2. They have formed from alluvium under somewhat poor natural drainage. All the Colo soils tend to be wet.

Colo silty clay loam, 0 to 1 percent slopes (Cd).—This soil probably developed under somewhat less favorable drainage than the other Colo soils mapped, and its subsoil is more slowly permeable. It is subject to flooding.

Typical profile:

A_{11} 0 to 12 inches, very dark gray to very dark brown (10YR 3/1 to 2/2) silty clay loam; somewhat hard when dry, slightly firm when moist; fine granular structure; neutral to slightly acid.

A_3–B_1 12 to 24 inches, very dark gray (10YR 3/1) silty clay loam; a few faint yellowish-brown mottles in the lower part of the layer; somewhat hard when dry, slightly firm when moist; fine granular structure; neutral to slightly acid.

B_1 24 to 30 inches, very dark gray to gray (10YR 3/1 to 5/1) silty clay loam, tending toward a silty clay; a few faint yellowish-brown mottles in lower part of the layer; hard when dry, firm when moist; fine granular structure; neutral to slightly acid.

C 30 to 45 inches, dark grayish-brown (10YR 4/2) silty clay loam; a few faint yellowish-brown and yellowish-red mottles; somewhat hard when dry, slightly firm when moist; fine granular structure; neutral to slightly acid.

VARIATIONS.—Some layering of silt loam and silty clay loam occurs in the uppermost foot of this soil. Variations in the subsoil texture indicate that some areas have formed from alluvial silty clay loam deposited over a former surface soil. This now buried layer consists of silty clay in some places. It may have been the surface soil of a Zook or Luton soil.

Use and management.—On this wet soil drainage generally needs continual attention. Unless tile lines are closely enough spaced, they may not function well because of the slow permeability of the subsoil. In areas where the substratum is silty clay, tile should be placed above this layer. Surface drainage will help, even though outlets for both tile and surface drains are commonly unsatisfactory.

This soil should not be tilled if it is wet, for it tends to puddle and clod on drying. Good tilth, however, is not so difficult to maintain as in the Luton clays. Some farmers fall-plow so that winter freezing and thawing will help to break down the larger clods. Return of crop residues and manure and growing grass-legume meadows will help to keep the granular tilth of the surface layer. This soil, like the other Colo soils, cannot be permanently harmed by heavy intertilled cropping; therefore, many different cropping systems can be used. Some farmers use a rotation of corn, soybeans, corn, oats, and meadow; others use fewer grain crops in the rotation. If the soil becomes cloddy and yields are reduced, 1 or 2 years in a legume-grass meadow should restore good tilth.

This soil has a medium content of available phosphorus and potassium. It is high in content of organic matter. Soil tests will help to determine what fertilizers are needed for the cropping system used. Lime usually is not required. This soil is in capability class II, subclass IIw.

Colo silty clay loam, moderately shallow over silt loam, 0 to 1 percent slopes (Ce).—This soil differs from the other Colo soils in the texture of the lower layers. Instead of silty clay loam, the texture is silt loam at depths of 30 to 50 inches. This soil is less wet and less stratified than Colo silty clay loam, 0 to 1 percent slopes. The subsoil is moderately permeable.

VARIATIONS.—In a few places, the texture is silty clay at depths of 30 to 50 inches.

Use and management.—This soil has a medium content of available phosphorus and potassium. The subsoil is generally moderately permeable, and ordinarily tile function satisfactorily if outlets are available. In other respects the use and management of this soil is similar to that of Colo silty clay loam, 0 to 1 percent slopes. This soil is in capability class II, subclass IIw.

Colo silty clay loam, calcareous variant, 0 to 1 percent slopes (Cg).—This soil has a moderately permeable subsoil and is strongly calcareous throughout.

Typical profile:

A1 0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay loam; somewhat hard when dry, slightly firm when moist; fine granular structure; highly calcareous; contains a few small fragments of snail shells.

AB 8 to 24 inches, very dark grayish-brown (10YR 3/2) silty clay loam; somewhat hard when dry, slightly firm when moist; fine granular structure; strongly calcareous.

BC 24 to 32 inches, olive-gray (5Y 4/2 to 5/2) silty clay loam; a few faint yellowish-brown mottles; somewhat hard when dry, slightly firm when moist, somewhat massive; strongly calcareous; because it has been frequently waterlogged, layer is gleyed.

D 32 to 45 inches, olive-gray (5Y 4/2 to 5/2) silt loam; a few faint yellowish-brown mottles; somewhat soft when dry, friable when moist; somewhat massive; strongly calcareous.

Use and management.—Because of the moderately permeable subsoil, tile usually can be used satisfactorily to drain this soil if outlets are available. This soil may need special applications of potassium and phosphate fertilizers. It has excess lime. Use and management is otherwise similar to that of Colo silty clay loam, 0 to 1 percent slopes. This soil is in capability class II, subclass IIw.

Cooper Soils

The Cooper soils, represented in this county by Cooper silty clay loam, 0 to 1 percent slopes, have formed from old alluvium laid down by the Missouri River. These soils are associated mainly with the Salix soils. Except for a finer textured substratum at depths of 30 to 40 inches, they are similar to Salix silty clay loam, 0 to 1 percent slopes. Little flooding has occurred on the Cooper soils in recent years. A few areas are slightly depressed and tend to pond. The Cooper soils are classed as Brunizems.

Cooper silty clay loam, 0 to 1 percent slopes (Ch).—This is an alluvial soil of the bottom lands. It is more inclined to be excessively wet than Salix silty clay loam, 0 to 1 percent slopes, with which it is associated.

Typical profile:

A1 0 to 7 inches, black to very dark gray (10YR 2/1 to 3/1) medium silty clay loam; slightly firm when moist; medium granular structure; slightly acid.

A3 7 to 12 inches, very dark grayish-brown (10YR 3/2) medium silty clay loam; slightly firm when moist; medium granular structure; slightly acid to neutral.

B1 12 to 20 inches, dark grayish-brown (10YR 4/2) medium silty clay loam; dark yellowish-brown mottles; slightly firm when moist; fine subangular blocky structure; slightly acid to neutral.

B3 20 to 30 inches, mixed dark grayish-brown, very dark grayish-brown, and dark yellowish-brown light silty clay loam; friable when moist; weakly developed subangular blocky structure; slightly acid to neutral.

D 30 to 40 inches, dark olive-gray (5Y 3/2) silty clay; firm when moist; fine to medium blocky structure; slightly acid to neutral.

VARIATIONS.—In places a layer of silt loam or silt occurs immediately above the fine-textured substratum. In some places the substratum is heavy silty clay, and in others it is clay. The Cooper soils mapped elsewhere generally have somewhat lighter colored upper layers than indicated in the typical profile given for Cooper silty clay loam, 0 to 1 percent slopes, and the color of the subsoil and substratum is light olive brown to olive brown. In many places the lower part of the subsoil and the substratum are calcareous.

Use and management.—Although wet, this soil is generally not so wet as Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes. Some areas may need surface drainage. If tile is used, the tile should be put above the silty clay substratum and not in it, because the substratum is somewhat slow in permeability. On wetter areas surface ditches usually improve the drainage.

Many different rotations can be used, because this soil has no serious management limitations. There is no erosion problem. A somewhat cloddy surface structure may develop, however, if the soil is cultivated when too wet. A granular structure is not especially difficult to maintain, but if the soil is plowed in fall, freezing and thawing will break down the large clods. If the plow layer becomes cloddy, an extra year of legume-grass meadow will also aid in restoring a granular surface structure.

Soil tests will provide a guide to needed fertilizers. This soil is in capability class II, subclass IIw.

Hamburg Soils

The Hamburg soils, represented in this county by Hamburg silt loam, 30 to 60 percent slopes, (fig. 5) have formed

***Figure 5.*—Hamburg silt loam, 30 to 60 percent slopes, on steep, catstep slopes.**

from loess on steep slopes. They are generally associated with the Ida and Monona soils. The soils are droughty. Runoff is rapid, and the Castana and other soils that lie below areas of the Hamburg soils are often gullied by the runoff waters. Native grasses are the principal vegetation. In some areas, especially on the north- and east-facing slopes, shrubs and small trees grow. The soils are classed as Regosols.

Hamburg silt loam, 30 to 60 percent slopes (Ha).—This soil resembles the virgin Ida soils. On its steep slopes, catstep or slump-formed benches are common.

Typical profile:

A1 0 to 4 inches, dark-brown (10YR 4/3) coarse silt to silt loam; soft when dry, friable when moist; fine granular structure; calcareous.

C 4 to 50 inches, pale-brown (10YR 6/3) coarse silt; soft when dry, friable when moist; calcareous with a few lime concretions.

VARIATIONS.—In a few areas the subsoil is light gray. A few faint yellowish-brown mottles occur in many areas.

Use and management.—This soil generally is not cultivated, and because of the steep slopes, few areas are suited to cultivation. As a rule the soil is used for pasture.

The best use for this soil is permanent pasture, but the yield of forage is low. The steep slopes make pasture renovation and care difficult. Native grasses are the principal vegetation on the pastures, but brush and trees often invade. It is best to restrict grazing so that the native grasses will be maintained.

The content of nitrogen and phosphorus is low in this soil. Application of fertilizer may not be warranted, however, because the slopes are too steep for machines to be used and the pastures make poor response to fertilizer. This soil is in capability class VII, subclass VIIe.

Haynie Soils

The Haynie soils occupy level or gently sloping areas near the Missouri River. They have formed from recently deposited Missouri River sediments. Some areas still receive deposits from the river when it overflows. Floods have not reduced yields on these soils as much as on some of the Albaton and Onawa soils, and floodwaters recede faster on these soils than on the lower lying areas of Albaton and Onawa soils. The Haynie soils are low in fertility. As a rule they are calcareous throughout. They are classified as Alluvial soils.

Haynie silt loam, 0 to 1 percent slopes (Hd).—Generally this soil has less fine sand in the subsoil than Haynie loamy fine sand, 0 to 2 percent slopes. In some places it borders the Salix soils.

Typical profile:

A_1 0 to 7 inches, very dark grayish-brown to dark grayish-brown (10YR 3/2 to 4/2) silt loam; soft when dry, friable when moist; granular or crumb structure, in some places platy; calcareous.

C_1 7 to 10 inches, dark grayish-brown (10YR 4/2) to light olive-brown (2.5Y 5/4) silt loam; soft when dry, friable when moist; crumb or granular structure that tends to be platy; calcareous.

C_{11} 10 to 60 inches, except for a few fine distinct yellowish-brown mottles, this layer is similar to the C_1 layer.

VARIATIONS.—Fine sand layers a few inches thick are fairly common in this soil. In a few areas, lenses of silty clay loam occur. Varying amounts of yellowish-brown mottles occur from place to place. In some places, where this soil lies next to Salix soils, the surface soil is free of carbonates and is somewhat darker colored than in the A_1 layer described for the typical profile.

Use and management.—If flooding is not a problem, Haynie silt loam, 0 to 1 percent slopes, can be used for many different crops and rotations. It is the most productive of the Haynie soils. Because of its surface layer of silt loam, good tilth is easily maintained and the soil can be tilled within a fairly wide range of moisture content. Underdrainage is usually adequate for corn and alfalfa. Under a high level of management, high yields of corn can be obtained.

The organic-matter content is low, and the content of available phosphorus is generally moderately low to low because of excessive lime. The amount of available potassium is moderately high in most areas. Soil tests will help to determine the kinds and amounts of plant nutrients needed. This soil is in capability class I.

Haynie fine sandy loam, 0 to 1 percent slopes (Hb).—This soil is more droughty than Haynie silt loam, 0 to 1 percent slopes.

Typical profile:

A_1 0 to 10 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; breaks into granules and sand when moist; weakly calcareous.

D_1 10 to 20 inches, very dark grayish-brown to dark grayish-brown (10YR 3/2 to 4/2) coarse silt loam; some very fine sand; friable when moist; structureless; weakly calcareous.

D_2 20 to 50 inches, dark grayish-brown coarse silt loam (thin layers of very fine sand are common, and horizon contains a few ½-inch layers of silty clay loam); strongly calcareous.

VARIATIONS.—The surface layer ranges from loamy fine sand to silt loam, but fine sandy loam is predominant. In most places the surface layer is calcareous, but in some it is neutral to very slightly acid. The proportion of silt loam and very fine sand varies in the subsoil, but the texture is mainly silt loam.

Use and management.—Wind erosion is a problem on this soil. Therefore, fall plowing should be avoided unless trash is left on the surface. Corn and soybeans are easily damaged by drifting sand; therefore, trash tilling or stripcropping with row crops and meadow may be needed. Most of this soil can be tilled within a wide range of moisture content.

This soil is low in organic matter, moderately low to low in available phosphorus, and somewhat low in available potassium. Soil tests will help to determine the need for plant nutrients. This soil is in capability class III, subclass IIIs.

Haynie loamy fine sand, 0 to 2 percent slopes (Hc).—This soil has a surface layer of loamy fine sand. Its subsoil contains more fine sand than the subsoil of the other Haynie soils. As a rule this soil is closely associated with the Sarpy soils, which it resembles. It grades toward the Sarpy soils in profile texture.

Use and management.—The sandier texture of this soil causes it to be more droughty than the other Haynie soils. Because of the texture of the surface layer, wind erosion is a serious problem. Fall plowing should be avoided unless trash is returned to the surface. Trash tilling and stripcropping may be needed to prevent drifting sand from damaging crops. It may be better to keep some of the larger areas in meadow. The soil can be tilled within a wide range of moisture content. It is low in organic-matter content, low to moderately low in available phosphorus, and somewhat low in available potassium. Soil tests will aid in determining the need for plant nutrients.

This soil is in capability class III, subclass IIIs.

Ida Soils

The Ida soils are extensive in the upland part of the county, where they occupy slopes of 1 to 50 percent (fig. 6). The soils have formed from loess. Their profiles do not contain distinct layers differentiated by color, texture, or structure, and the soils are therefore classed as Regosols. These soils are closely associated with the Hamburg, Monona, and Castana soils (fig. 3). Included in some of the mapping units are small areas of severely eroded steep phases of Monona soils and small areas of Dow soils. The Dow soils, not mapped in this county, are

Figure 6.—**Ida soils on steep slopes and narrow ridges in Monona County.**

similar in texture and consistence to the Ida soils, but below the surface layer, they are light olive gray in color. A profile description of a slightly eroded Dow silt loam follows the profile description of Ida silt loam, 1 to 7 percent slopes.

The Ida soils have developed under prairie vegetation. In a few areas, however, brush and small trees have encroached. Most of the Ida soils have been cultivated, and in most areas the original moderately dark organic surface layer has been washed away.

Ida silt loam, 1 to 7 percent slopes (Ia).—Most of this soil has been cultivated, and little of the original surface layer remains.

Typical profile in virgin or uneroded area:

A_1 0 to 8 inches, very dark grayish-brown (10YR 3/2) medium silt loam; contains about 15 percent clay, about 80 percent silt, and little or no sand; friable when moist; fine granular structure; calcareous.

C_1 8 to 20 inches, dark yellowish-brown (10YR 4/4) medium silt loam; contains faint small mottles and spots of yellowish brown and light olive gray (5YR 6/2); friable when moist; structureless; calcareous.

C_2 20 to 80 inches, except that brownish-yellow and light olive-gray mottles are somewhat more distinct, this layer resembles the C_1 layer.

VARIATIONS.—Most Ida silt loam, 1 to 7 percent slopes, is eroded. The surface layer in the eroded areas is generally dark grayish brown when moist.

Profile description of slightly eroded Dow silt loam:

A_p 0 to 7 inches, dark-gray (10YR 4/1) silt loam; friable when moist.

C 7 to 50 inches, olive-gray to light olive-gray (5Y 5/2 to 6/2) medium silt loam; friable; calcareous.

Use and management.—Because it is calcareous throughout, a large part of this soil is extremely low in available phosphorus. Research at the Western Iowa Experimental Farm near Castana has shown that yields of corn, alfalfa, and oats have been materially increased when adequate amounts of phosphate have been added.

The amount of available nitrogen and the total content of nitrogen are low in this soil. Commonly, available potassium is moderately high. The content of lime is generally excessive.

Because of its slopes and silty texture, this soil is very susceptible to erosion. Raindrops falling on the bare silty surface layer readily destroy the soil structure, which is difficult to form and to maintain, even under grass. Erosion should be reduced or minimized by plowing on the contour and by building terraces. The terraces must be carefully designed and constructed, so a local representative of the Soil Conservation Service or the county extension director should be consulted for help.

A suggested rotation if this soil is terraced and farmed on the contour is corn 2 years, oats 1 year, and meadow 1 year. This soil is in capability class III, subclass IIIe.

Ida silt loam, 7 to 14 percent slopes (Ib).—Except for stronger slopes and greater susceptibility to erosion, this soil resembles Ida silt loam, 1 to 7 percent slopes.

Use and management.—In most places this soil is extremely low in available phosphorus, fairly low in available nitrogen, and moderately high in potassium. It is calcareous throughout. Except that an additional year of meadow should be added to the rotation, management practices are the same as for Ida silt loam, 1 to 7 percent slopes. The soil is in capability class III, subclass IIIe.

Ida silt loam, 14 to 22 percent slopes (Ic).—Except that it is more susceptible to erosion, this soil is similar to the Ida silt loams that occupy milder slopes.

Use and management.—The use and management of this soil is like that of Ida silt loam, 1 to 7 percent slopes, except that terraces are used only on the gentle slopes. If nitrogen and phosphate are added and contouring and terracing used, a rotation of corn 1 year, oats 1 year, and meadow 2 years can be used. If contoured only, this soil should be kept in permanent vegetation or cropped, using a rotation of corn 1 year, oats 1 year, and meadow 3 years. This soil is in capability class IV, subclass IVe.

Ida silt loam, 22 to 30 percent slopes (Id).—This soil is eroded. Except for steeper slopes, it is similar to the eroded areas of Ida silt loam, 1 to 7 percent slopes.

Use and management.—Soils that have slopes greater than 15 to 20 percent are not suitable for terraces, so terraces should not be constructed on this soil. If the soil is cultivated on the contour, a rotation of corn 1 year, oats 1 year, and meadow 4 or more years can be used. An alternative use is pasture. In other respects this soil is used and managed in about the same way as Ida silt loam, 1 to 7 percent slopes. It is in capability class VI, subclass VIe.

Ida silt loam, 30 to 50 percent slopes (Ie).—This soil is similar to the other Ida silt loams but has steeper slopes and is more severely eroded.

Use and management.—It would not be feasible to construct terraces on this soil, and the areas should be used for pasture. Careful pasture management is needed to prevent excessive erosion on this strongly sloping soil. It is in capability class VII, subclass VIIe.

Kennebec Soils

Although one of the soils mapped in this series is a calcareous variant, the Kennebec soils in Monona County are all silt loams. They occur along streams flowing through the uplands and onto the bottom lands of the Missouri River. Like Haynie silt loam, 0 to 1 percent slopes, these soils are forming from silty stream-laid deposits. Generally they are older than the Haynie and McPaul soils. They are classed as Brunizems.

Kennebec silt loam, 0 to 1 percent slopes (Ka).—This is a fairly fertile soil that, in some places, is subject to flooding.

Typical profile:

A_1 0 to 12 inches, very dark brown (10YR 2/2) silt loam; friable when moist; fine granular structure; slightly acid to neutral.

A_3B_1 12 to 30 inches, very dark grayish-brown (10YR 3/2) silt loam with a few faint yellowish-brown mottles; friable when moist; fine, indistinct, weak subangular blocky structure; neutral to very slightly acid.

C_1 30 to 45 inches, dark grayish-brown to dark-gray (10YR 4/2 to 4/1) silt loam with a few faint yellowish-brown mottles; friable when moist; fine, indistinct, granular structure; weakly calcareous.

D_1 45 to 55 inches, dark grayish-brown (10YR 4/2) lenses of fine sand or silt loam; friable when moist; no distinct structure; moderately calcareous.

VARIATIONS.—Some areas, especially those that lie next to Colo and Zook soils, have a black surface layer. In a few places, the texture of the lower layers is silty clay instead of silt loam. In areas that adjoin the McPaul soil, a thin layer of calcareous silt loam occurs in places in the surface soil. In areas that adjoin the Napier soil, the subsoil contains more yellowish material than occurs in the typical profile.

Use and management.—Floods sometimes limit the use of Kennebec silt loam, 0 to 1 percent slopes. The areas are flooded if dikes and banks give way when the water is high. The frequency and severity of floods vary on different areas. Normally, this soil does not need artificial drainage to grow corn and alfalfa. It has moderate permeability, and tile drainage would function well if needed.

This soil generally has enough lime for crops. It has a moderate to high content of available phosphorus, potassium, and nitrogen.

Because flooding varies on different areas of the soil, it is not possible to suggest a rotation suited to all areas. Where flooding is not a hazard, or can be prevented, the soil is suited to corn. Areas that are frequently or seriously flooded should be used for trees or permanent pasture. This soil is in capability class I.

Kennebec silt loam, calcareous variant, 0 to 1 percent slopes (Kb).—This soil occurs on the old Missouri River bottoms. It has formed from silty alluvium.

Typical profile:

A_1 0 to 16 inches, black to very dark gray (10YR 2/1 to 3/1) silt loam; friable when moist; fine granular structure; medium to strongly calcareous.

C 16 to 38 inches, dark-gray (10YR 4/1) silt loam in the upper part and grayish-brown (10YR 5/2) silt loam in the lower part; a few faint yellowish-brown mottles in the lower part; friable when moist; indistinct structure; strongly calcareous.

Use and management.—This soil has good tilth and is moderately permeable. It is calcareous throughout. The soil is subject to some flooding. It is low in nitrogen and probably low in available phosphorus and potassium, but soil tests should be made to determine the kind and amount of fertilizer needed.

Because of the nearly level relief and good tilth, ordinarily this soil can be used extensively for corn. It is in capability class II, subclass IIw.

Luton Soils

The Luton soils occur mainly on nearly level areas in the central part of the Missouri River bottom lands. A few isolated areas occur farther east where the smaller rivers emerge onto the broad bottom lands. The soils have formed under swampgrasses from river deposits high in clay. Some areas of the Luton soils are flooded when dikes and drainage ditches break. A few areas receive some floodwaters from the Missouri River. The soils are classed as Humic Gley (Wiesenboden).

Luton clay, 0 to 1 percent slopes (La).—The texture of this soil is generally uniform to depths of 4 or 5 feet.

Typical profile:

A_1 0 to 6 inches, black (10YR 2/1) clay (about 50 percent clay, about 40 percent silt, and a little sand), firm to very firm when moist; hard when dry and tends to be cloddy; fine granular structure; neutral to slightly acid.

A_1A_3 6 to 14 inches, very dark gray (10YR 3/1) clay (similar to the surface layer in texture and consistence).

B_2 14 to 24 inches, very dark gray (10YR 3/1) clay; firm to very firm when moist; hard when dry; very fine angular blocky structure; neutral to slightly acid.

B_3 24 to 36 inches, dark grayish-brown (10YR 4/2) clay in upper part, but color grades to dark gray (10YR 4/1); in lower part, medium distinct yellowish-brown mottles; when moist, firm to very firm; moderate to strong very fine blocky structure; neutral to very slightly acid.

C 36 to 50 inches, dark-gray (10YR 4/1) to olive-brown (2.5Y 4/4) clay; distinct yellowish-brown mottles; firm to very firm when moist, hard when dry; fine blocky structure; neutral; because of the generally high water table, layer has been somewhat modified since the material was deposited; high water table has caused poor aeration, so layer has a mottled gray color.

VARIATIONS.—The thickness of the dark surface and subsurface layers ranges from about 10 to 20 inches. The B and C horizons, though generally dark gray, in places are yellowish to olive gray. In some places silty layers and lenses of a few inches to occasionally a foot thick occur within 3 to 4 feet of the surface. Apparently these are not continuous and do not have any appreciable effect on the internal drainage or surface drainage.

Although the surface layers are generally neutral, a few areas are slightly calcareous and contain a few snail shells. In many places the B and C horizons are calcareous and contain lime concretions.

In some areas, where this soil occurs near the Albaton soil, it is difficult to distinguish between it and the Albaton soil. A variation or intergrade of Luton-Albaton soils is not so dark as Luton clay, 0 to 1 percent slopes but is darker than the typical Albaton soil. This intergrade was generally mapped as Luton clay, 0 to 1 percent slopes.

The lighter colored variation of Luton clay, 0 to 1 percent slopes, commonly occurs near areas of Luton clay, overwash phase, 0 to 1 percent slopes. The sediments from which this variation developed probably were laid down fairly rapidly, as there is no evidence of buried soils. They were probably laid down more recently than the sediments from which Luton clay, 0 to 1 percent slopes, developed and somewhat earlier than the sediments from which the Albaton soil is forming.

Use and management.—The most difficult management problems on Luton clay, 0 to 1 percent slopes, are drainage, the establishment of a stand, and weed control. Tile drainage is not feasible because of the high clay content and resulting low permeability of the soil. Surface drainage is difficult because this soil occurs in large, nearly level areas so that it is difficult to obtain enough grade to prevent ponding between surface ditches. It is also difficult to obtain outlets for the ditches. The soil puddles badly if worked when it is wet, and it may be cloddy if worked dry. It is frequently impossible to prepare a satisfactory seedbed, so stands are poor in many years.

Crops cannot be cultivated when this soil is wet, so weeds frequently are not adequately controlled.

Corn, soybeans, and wheat are the principal crops grown. Regular rotations are not generally followed. Some alfalfa is grown. Once established, it grows well in dry seasons but is drowned out in seasons of above-normal rainfall. On the average, according to census records, about 20 percent of the crops are not harvested, usually because they are damaged or ruined by excess water or weeds. This soil is in capability class III, subclass IIIw.

Luton clay, overwash phase, 0 to 1 percent slopes (Lb).—This soil has a clay overwash over a profile similar to that of Luton clay, 0 to 1 percent slopes. The overwash layer is very dark grayish brown to dark grayish brown when moist. It is a clay deposit laid down by the Missouri River at flood stage. Probably it was laid down at the same time that the Albaton and Onawa soil materials were deposited. This layer is generally 4 to 15 inches thick and is composed of about 50 percent clay, about 40 percent silt, and a little sand. It has fine granular or fine angular blocky structure. When it is moist, firm pressure is necessary to mold it.

VARIATIONS.—The buried profile below the overwash layer has properties and variations similar to those of Luton clay, 0 to 1 percent slopes.

Use and management.—Wetness and cultivation problems are ordinarily slightly less acute and less difficult for Luton clay, overwash phase, 0 to 1 percent slopes, than for Luton clay, 0 to 1 percent slopes. Soil properties, use, and management are generally the same as those described for Luton clay, 0 to 1 percent slopes. This soil is in capability class III, subclass IIIw.

Luton silty clay, moderately shallow over silty clay loam, 0 to 1 percent slopes (Lc).—This soil generally has slightly less clay in the surface soil than Luton clay, 0 to 1 percent slopes, and has silt loam or silty clay loam at depths between 36 and 50 inches. The boundaries between this soil and Luton clay, 0 to 1 percent slopes, are not everywhere distinct. This is also true of the boundaries between this soil and the Zook soils and between this soil and Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes.

Typical profile:

A_1 0 to 8 inches, black (10YR 2/1) silty clay; contains about 40 to 45 percent clay, 45 to 50 percent silt, and a little sand; firm when moist; fine granular structure; neutral to slightly acid.

B_2 8 to 20 inches, very dark grayish-brown (10YR 3/2) clay; contains a few distinct olive mottles; firm to very firm when moist; very fine angular blocky structure; hard when dry; neutral to slightly acid.

B_{21} 20 to 30 inches, very dark grayish-brown firm clay; contains common distinct medium olive (5Y 4/5) mottles; moderately strong very fine angular blocky structure.

B_3 30 to 36 inches, somewhat grayer and contains slightly less clay than the layer immediately above it; other properties are similar.

D_1 36 to 42 inches, olive-brown (2.5Y 4/4) firm silty clay loam; common fine prominent light olive-brown (2.5Y 5/6) mottles; moderate very fine subangular blocky structure.

D_2 42 to 50 inches, light olive-brown (2.5Y 5/4, moist) silt loam or silty clay loam; contains fine distinct light-olive mottles; friable when moist; calcareous.

Use and management.—This soil is generally not so wet as Luton clay, 0 to 1 percent slopes. Wetness and cultivation problems are generally less serious than they are for Luton clay, 0 to 1 percent slopes.

Except for the slight differences indicated, the properties and management are the same for this soil as for the Luton clays. The soil is in capability class III, subclass IIIw.

McPaul Soils

Only one of the McPaul soils, McPaul silt loam, 0 to 2 percent slopes, is mapped in Monona County. The McPaul soils occur along streams and ditches in the uplands and along streams that flow from the uplands. The soils are forming from recently deposited silty sediments, most of which have been deposited during the past 50 years. Each time the streams and ditches overflow, new deposits are added. The sediments consist of materials washed from the dark-colored surface layer of other soils or of material washed from other soils when gullies were formed. The materials are generally calcareous.

Because roads and fences have determined the course of the floodwaters in many places, they have also frequently determined the boundaries of these soils. These soils are classified as Alluvial.

McPaul silt loam, 0 to 2 percent slopes (Ma).—This soil has nearly level relief, and most slopes are less than 1 percent. It is frequently flooded.

Typical profile:

C 0 to 45 inches, dark grayish-brown to dark yellowish-brown (10YR 4/2 to 4/4) medium silt loam; contains a few faint yellowish-brown mottles; friable when moist; fine granular structure; weakly calcareous throughout.

A_b 45 inches +, black (10YR 2/1) silty clay loam; where this buried soil was examined, it resembles Colo silty clay loam, 0 to 1 percent slopes.

VARIATIONS.—The chief variations are in the buried soil, or A_b horizon. Although the buried soil generally occurs at depths of more than 3 feet, in a few areas it occurs at a depth of only 2 feet. There is some variation in texture as well. In most places the buried soil resembles the Colo silty clay loams or Zook silty clays, but in a few places it resembles Luton clay, 0 to 1 percent slopes.

In some places the upper layer, when moist, is light yellowish brown. In some areas 1- to 3-inch layers of dark- and light-colored material are in the same profile. The yellowish-brown mottles vary in abundance but generally occur throughout the upper layer. Although the texture of the upper layer in most places is silt loam, in a few places thin lenses of silty clay loam occur.

Use and management.—McPaul silt loam, 0 to 2 percent slopes, is subject to flooding. Some areas are frequently and severely flooded, but others that are protected by dikes or road embankments are seldom flooded. Some areas need artificial drainage, and tile drains generally are satisfactory. Where the buried soil is clay, the tile should be placed above the clay and not in it. This soil should be protected by dikes and, where needed, the surface water removed by ditches or pumping.

This soil is easy to keep in good tilth. It does not need lime. Many areas are low in available nitrogen, but the soil generally has moderate to high amounts of available phosphorus and potassium. Although the soil is fairly fertile, it is best to make soil tests. If flooding and wetness are no special problem, the soil is highly suitable for corn and soybeans. A legume-grass meadow is not particularly needed in the rotation. Some areas should be kept in permanent pasture or trees. This soil is in capability unit I.

Mixed Alluvial Land

Mixed alluvial land is a miscellaneous land type. It is composed of the most recent sediments deposited by rivers during floods. The sediments are of various textures. There is no well-defined profile.

Mixed alluvial land (Mb).—In Monona County this land type is near the Missouri River. Each flood adds new sediments. Sometimes clay is deposited on sand, and sometimes sand on clay. Some areas of Albaton, Modale, and Sarpy soils are included in this mapping unit. The vegetation consists of trees, brush, and swamp plants.

Use and management.—Flooding is the chief problem on this land type. The land is often wet. It is generally moderately low in fertility and is especially low in available nitrogen and phosphorus. Some areas have been cleared and occasionally planted to corn and other crops, but the crops are often ruined by floods. Some areas of silt loam and silty clay loam that have been cleared and planted to crops have been covered with 2 feet or more of sand after planting. Because of the risk of floods, it is not practical to fertilize. This land type is in capability class V, subclass Vw.

Modale Soils

The Modale soils occupy nearly level areas within a few miles of the Missouri River. They are forming in sediments recently deposited by that river. Some areas have received sediments from floodwaters of the Missouri River as recently as 1952.

The Modale soils resemble the Haynie soils in the upper layers and the Albaton soils in the subsoil and lower layers. They are classed as Alluvial.

Modale silt loam, 0 to 1 percent slopes (Mc).—This weakly developed soil is calcareous throughout.

Typical profile:

A_1 0 to 10 inches, very dark gray (10YR 3/1) silt loam; contains a few faint yellowish-brown mottles; friable when moist; fine granular structure; weakly calcareous.

C_1 10 to 20 inches, very dark gray to very dark grayish brown (10YR 3/1 to 3/2) silt loam containing a small amount of fine sand; faint yellowish-brown mottles; friable when moist; fine granular structure; weakly calcareous.

C_2 20 to 25 inches, grayish-brown (10YR 5/2) silt loam with a few fine sand lenses one-half inch thick; contains a few red mottles; friable when moist; fine granular structure; weakly calcareous.

D_1 25 to 50 inches, very dark gray (10YR 3/1) medium silty clay (about 50 percent clay and little or no sand); firm when moist, very hard when dry; fine blocky structure; weakly calcareous.

VARIATIONS.—Although the silty clay D_1 layer in most places begins at a depth of 25 inches, in some areas it begins at a depth of only 15 inches. In others it is as deep as 35 inches. In some places, no thin lenses of fine sand occur.

Use and management.—Most of this soil is adequately drained, but in some years a few areas are rather wet. If tile is used it should be placed in the silt loam layer, because the silty clay subsoil is too slowly permeable for tile to function well. Surface ditches can be used where needed. Water erosion is not a problem.

Much of this soil is low in plant nutrients, especially in available phosphorus. The content of organic matter is low. The soil does not need lime; it is calcareous throughout. Soil tests are the best way of determining the need for plant nutrients for different crops. Corn and soybeans can be grown in most years. If the soil is fertilized properly, fairly good yields of corn are obtained. Good tilth is easy to maintain, and legume-grass meadow is not needed often in the rotation to maintain tilth. This soil is in capability class I.

Modale sandy loam, 0 to 1 percent slopes (Md).—This soil is similar to Modale silt loam, 0 to 1 percent slopes, but it is droughty and subject to wind erosion.

Typical profile:

A_1 0 to 10 inches, very dark grayish-brown (10YR 3/2) sandy loam; friable when moist; fine granular structure; mildly calcareous.

C_1 10 to 20 inches, very dark grayish-brown (10YR 3/2) fine sandy loam with thin lenses of silt; contains a few faint yellowish-brown mottles; friable when moist; indistinct granular structure; strongly calcareous.

D_1 20 to 25 inches, very dark grayish-brown (10YR 3/2) silty clay; firm when moist; fine distinct blocky structure; moderately calcareous.

VARIATIONS.—The silty clay layer occurs at varying depths of 15 to 35 inches. The common depth is about 20 inches.

Use and management.—If wind erosion can be prevented, this soil can be used in the same rotations as Modale silt loam, 0 to 1 percent slopes, but it is more droughty and less productive. It is in capability class II, subclass IIs.

Monona Soils

The Monona soils occur in the uplands. They have formed from loess under prairie vegetation. Water erosion, mainly sheet erosion, is a problem on all of these soils. Some areas have lost all of the original surface layer through erosion. Where these soils merge with areas of the Napier soil, however, the surface layer, or A_1 horizon, is somewhat thicker and darker than that described in the typical profile of Monona silt loam, 1 to 7 percent slopes. The Monona soils are classified as Brunizems.

Monona silt loam, 1 to 7 percent slopes (Me).—Most of the original surface layer remains on this soil, but there are some small eroded areas. In most places calcareous loess occurs below depths of 40 to 50 inches.

Typical profile:

A_1 0 to 6 inches, very dark brown (10YR 2/2) silt loam; friable when moist; fine granular structure; slightly acid.

A_3 6 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam; friable when moist; mainly granular but some blocky structure; slightly acid.

B_2 12 to 24 inches, mostly dark-brown (10YR 4/3) silt loam (contains almost enough clay to be classed as light silty clay loam); some very dark grayish brown in upper part; friable when moist; indistinct fine blocky structure; slightly acid.

B_3 24 to 36 inches, dark yellowish-brown and some dark-brown (10YR 4/4 and 4/3) silt loam; friable when moist; indistinct fine blocky structure; slightly to very slightly acid.

C_1 36 to 50 inches, mainly dark yellowish-brown and yellowish-brown (10YR 4/4 and 5/4) silt loam; (the clay content lower than in the A_1 layer); some light olive-gray and strong-brown mottles; friable when moist; structureless; neutral.

VARIATIONS.—The C horizon of this soil lies at greater depths than in the more sloping Monona soils. Where this soil occurs in the eastern part of association 4, its B horizon has a somewhat greater content of clay than where the soil occurs in association 5.

Use and management.—This soil is erodible, but it is less eroded than the other Monona soils. It is moderately permeable so that level terracing and listing on the contour can be used to help control erosion. As further protection, 1 year of legume-grass meadow generally should be included in the rotation following 2 years of corn and 1 year of oats.

The B and C horizons are porous and do not become waterlogged, so this soil is seldom too wet. A surface crust rarely forms, and most of the rainfall can be made to penetrate the B and C horizons by tilling on the contour and terracing. Corn and alfalfa on this soil are often damaged, however, because there is not enough rainfall.

Although originally moderately high in organic matter, this soil is now generally low in available nitrogen. The content of available potassium is normally high to very high. The content of available phosphorus varies but is generally higher in this soil than in the other Monona soils. Generally, this soil does not need lime, but lime may be needed for alfalfa. It is best to have the soil tested to determine the need for plant nutrients for the different crops. This soil is in capability class II, subclass IIe.

Monona silt loam, 1 to 7 percent slopes, eroded (Mg).—Except for having lost some of its original surface layer through erosion and now having a dark-brown to dark yellowish-brown plow layer, this soil resembles Monona silt loam, 1 to 7 percent slopes. It is low in nitrogen. In other respects its properties, use, and management are similar to those of Monona silt loam, 1 to 7 percent slopes. This soil is in capability class II, subclass IIe.

Monona silt loam, 7 to 14 percent slopes (Mh).—This soil, except for slope, resembles Monona silt loam, 1 to 7 percent slopes, and its use and management are similar. Moisture is a more limiting factor, however, and the soil must be managed more carefully to protect against erosion. This soil is in capability class III, subclass IIIe.

Monona silt loam, 7 to 14 percent slopes, eroded (Mk).—The plow layer of this soil is dark brown to dark yellowish brown when moist. The profile is otherwise similar to that of Monona silt loam, 1 to 7 percent slopes.

This soil is low in nitrogen. In other respects its properties, use, and management are similar to those of Monona silt loam, 1 to 7 percent slopes. More careful management is necessary, however, to protect against erosion. This soil is in capability class III, subclass IIIe.

Monona silt loam, 14 to 22 percent slopes (Mm).—Except that it has stronger slopes, this soil is similar to Monona silt loam, 1 to 7 percent slopes. It requires more careful management than Monona silt loam, 1 to 7 percent slopes. Terraces may be used on the milder slopes. Corn should be grown only on terraced and contoured fields and for 1 year in the rotation. This soil is in capability class IV, subclass IVe.

Monona silt loam, 14 to 22 percent slopes, eroded (Mn).—The plow layer of this soil is dark brown to dark yellowish brown when moist. This soil and Monona silt loam, 22 to 30 percent slopes, eroded, have a siltier surface layer than the other Monona soils. In many places calcareous loess occurs at depths of 20 to 40 inches. The profile otherwise resembles that of Monona silt loam, 1 to 7 percent slopes.

Many small areas of Ida soils that are steeper than typical areas of this mapping unit are included. It is possible that in the future more of these areas will become large enough to be mapped as Ida soils if erosion continues at the same rate as in the past 50 years.

Use and management.—A stable structure is harder to maintain in Monona silt loam, 14 to 22 percent slopes, eroded, than in soils with a less silty surface layer. Lime is not generally needed for alfalfa, but the nitrogen content is very low. The supply of available phosphorus is lower than in Monona silt loam, 1 to 7 percent slopes, but the other properties are about the same. Terraces can be used on the milder slopes. It is difficult to control erosion, even on terraced fields, if row crops are grown. Erosion will proceed at a very rapid rate if more than 1 year of a clean-cultivated crop is used in the rotation. In other respects this soil can be used and managed about the same as Monona silt loam, 1 to 7 percent slopes. It is in capability class IV, subclass IVe.

Monona silt loam, 22 to 30 percent slopes (Mo).—Except that in many places calcareous loess occurs at depths of less than 40 inches, this soil is similar to Monona silt loam, 1 to 7 percent slopes.

Use and management.—Because of the steeper slopes, runoff is more rapid than on Monona silt loam, 1 to 7 percent slopes. Terraces cannot be used on this soil; therefore, rainfall is less likely to penetrate the B and C horizons than on terraced soils.

A close-growing cover will help protect this soil from erosion. The soil is not suited to row crops but is suited to permanent pasture. If row crops are grown, a suggested rotation is corn 1 year, oats 1 year, and meadow 4 or more years. Corn and alfalfa may be damaged by the shortage of moisture. This soil is in capability class VI, subclass VIe.

Monona silt loam, 22 to 30 percent slopes, eroded (Mp).—Most of the original surface layer of this soil has been lost through water erosion. The present plow layer is dark brown to dark yellowish brown when moist. This soil, like Monona silt loam, 14 to 22 percent slopes, eroded, has a siltier surface layer than the other Monona soils. Calcareous loess occurs in many places at depths of 20 to 40 inches. Generally the profile otherwise resembles that of Monona silt loam, 1 to 7 percent slopes.

If erosion continues at the same rate as in the past 50 years, it is probable that most of Monona silt loam, 22 to 30 percent slopes, eroded, will sometime be classed as an Ida soil. Many areas of Ida silt loam, 22 to 30 percent slopes, are included in this mapping unit.

Use and management.—Because of the siltier surface layer, a stable structure is harder to maintain in Monona silt loam, 22 to 30 percent slopes, eroded, than in most of the Monona soils. This soil has a very low supply of available nitrogen and less of available phosphorus than Monona silt loam, 1 to 7 percent slopes. The content of available potassium is normally high.

The use and management of this soil are the same as for uneroded Monona silt loam, 22 to 30 percent slopes. This soil is less productive than the uneroded phase. It is in capability class VI, subclass VIe.

Monona silt loam, 30 to 40 percent slopes (Mr).—The plow layer of this soil is dark brown to dark yellowish brown when moist. In most areas calcareous loess occurs at depths of less than 40 inches. Otherwise the profile resembles that of Monona silt loam, 1 to 7 percent slopes.

Numerous areas of Ida silt loam, 30 to 40 percent slopes, are included in this mapping unit. If erosion continues at the same rate as in the past 50 years, it is probable that this mapping unit eventually will be classed as an Ida soil.

Use and management.—Terraces cannot be used on Monona silt loam, 30 to 40 percent slopes. This soil is best used for permanent pasture. It is in capability class VII, subclass VIIe.

Napa Soils

The Napa soils occur in small areas, each about an acre in size. Some areas are so small that they are indicated on the map by alkali-spot symbols. Normally, they occur in slight depressions within larger areas of Luton soils. They contain exchangeable sodium and are true alkali soils. Below a thin surface layer, their texture is silty clay throughout. They are classed as Humic Gley (Wiesenboden) soils but resemble the Solonetz soils. In this county there is only one soil of this series, Napa clay, 0 to 1 percent slopes.

Napa clay, 0 to 1 percent slopes (Na).—This poorly drained soil occurs in slight depressions within larger areas of Luton soils.

Typical profile:

A_1 0 to 9 inches, very dark gray (10YR 3/1) silty clay; hard when dry, firm when moist; coarse blocky structure in upper part of layer, or plow layer, and medium blocky below; because of the exchangeable and water-soluble sodium, slightly alkaline but noncalcareous.

B 9 to 14 inches, very dark gray (10YR 3/1) silty clay; firm when moist; medium blocky structure; because of the soluble and exchangeable sodium, reaction is alkaline; soil is also calcareous.

C_1 14 to 20 inches, mostly dark gray (10YR 4/1) silty clay; some olive-brown (2.5Y 4/4) mottles; firm when moist; medium blocky structure; because of the soluble and exchangeable sodium, reaction is alkaline; soil is also calcareous.

C_2 20 to 28 inches, olive-gray (5Y 5/2) silty clay; olive-brown mottles; very hard when dry, firm when moist; because of the soluble and exchangeable sodium, reaction is alkaline; soil is also calcareous.

28 to 60 inches, olive-gray silty clay; olive-brown mottles.

VARIATIONS.—In some places a one-fourth to one-half inch layer of dark-gray (10YR 4/1) silt loam, friable when moist, with a layered or platy structure overlies the A_1 horizon. This layer has apparently accumulated during rains.

Use and management.—The problem of wetness in this soil is even more severe than in Luton clay, 0 to 1 percent slopes. Because it occurs in slight depressions, excess surface water is hard to remove. Shallow surface drains are effective in some areas. The soil normally puddles. It clods when cultivated. Because of the clay subsoil, water percolates too slowly for tile to function. Therefore, gypsum and sulfur, which can be used in dry areas to remove excess sodium, probably would not be effective on this soil.

Little improvement of this soil can be expected. The soil is usually cropped the same as surrounding Luton soils, but estimated yields are considerably lower. It is in capability class IV, subclass IVw.

Napier Soils

The Napier soils, represented in this county by Napier silt loam, 4 to 10 percent slopes, occur along upland drainageways and narrow streams and on footslopes. They have formed from material washed from slopes where the Monona, Ida, Castana, and Hamburg soils are dominant. As all these soils are high in silt, the Napier soils are silty. Most of the materials were washed down slowly a long time before the soils were cultivated, and rather indistinct horizons have had time to develop. The Napier soils are Brunizems.

Napier silt loam, 4 to 10 percent slopes (Nb).—This soil has thick dark upper layers and moderately dark to yellowish-brown lower layers. Except in the areas where it lies next to Monona soils, the upper layers are thicker and darker than those of Monona silt loam, 1 to 7 percent slopes.

Typical profile:

A_1 0 to 10 inches, black to very dark brown (10YR 2/1 to 2/2) silt loam; friable when moist; fine granular structure; slightly acid.

A_3 10 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam; friable when moist; indistinct, fine subangular blocky structure; slightly acid.

A_3B_1 20 to 30 inches, dark grayish-brown (10YR 4/2) silt loam; contains about enough clay to be classed as a light silty clay loam; friable when moist; indistinct fine subangular blocky structure; slightly acid.

C_1 30 to 45 inches, chiefly dark grayish-brown (10YR 4/2) silt loam; contains a few faint yellowish-brown mottles; friable when moist; indistinct structure more granular than blocky; slightly acid to nearly neutral.

VARIATIONS.—As a rule the nearly level areas of Napier silt loam, 4 to 10 percent slopes, especially the areas near the middle of drainageways, have some dark gray in the lower layers and a moderate amount of yellowish-brown mottles. Calcium carbonate, in some places, causes an alkaline reaction in the lower layers. In some areas the calcium carbonate occurs at depths of 20 to 25 inches. Many areas of Napier silt loam, 4 to 10 percent slopes, have received recent sediments that have formed a layer, up to 10 inches thick, on the surface. These sediments were washed mainly from Ida and Monona soils, partly through gully erosion. Their color and texture are similar to the dark grayish-brown silt loam surface layer of the McPaul soil.

Use and management.—The principal problem on Napier silt loam, 4 to 10 percent slopes, is gullying, especially in the middle of drainageways. Areas that lie below the steeper Ida and Monona soils receive large amounts of runoff, and where runoff waters concentrate, deep gullies may develop. Grassed waterways should be maintained permanently to protect this soil. If gullying is controlled, areas other than the grassed waterways will be safeguarded. If the surrounding slopes are not too steep, runoff often can be effectively controlled by tilling on the contour and using level terraces.

This soil is moderately high in plant nutrients. Tilth is normally no problem. Although some areas are subject to overflow for short periods, the soil is seldom too wet.

This soil is more suitable for corn when a rotation is used that includes 1 year of meadow following 2 years of corn and 1 year of oats. Where practicable, cultivation should be on the contour. This soil is in capability class III, subclass IIIe.

Onawa Soils

The Onawa soils occur on nearly level areas within a few miles of the Missouri River. They have formed from recently deposited sediments, probably laid down in the last few hundred years, some during the flood of 1952.

These soils are commonly associated with the Albaton soil. They have Alluvial profiles.

Onawa silty clay, 0 to 1 percent slopes (Oa).—This soil, like the Haynie, Modale, and Albaton soils, has formed from sediments deposited by the Missouri River.

Typical profile:

A_1 0 to 7 inches, dark grayish-brown to very dark grayish-brown (10YR 4/2 to 3/2) silty clay (about 50 percent clay and little or no sand); firm when moist; fine granular structure; weakly calcareous.

C 7 to 30 inches, dark grayish-brown (10YR 4/2) silty clay; very hard when dry, firm to very firm when moist; cloddy when dry, fine blocky structure; weakly calcareous.

D 30 to 50 inches, mostly dark gray to dark grayish-brown (10YR 4/1 to 4/2) silt loam; in places alternate layers of silt and fine sand occur; yellowish-brown and dark reddish-brown mottles are common; friable when moist; structure is indistinct but tends to be platy; strongly calcareous.

VARIATIONS.—In some places, the D layer begins at a depth of only 20 inches and in other places at a depth of 36 inches. The texture of the D layer, in some places, is fine sand. Some areas have thin dark-colored layers in the lower horizons. These thin layers are former A_1 layers that are now buried. In a few places there is a buried profile resembling that of Salix silt loam, 0 to 1 percent slopes.

Use and management.—Onawa silty clay, 0 to 1 percent slopes, is generally low in most plant nutrients, although the content of available potassium is moderately high. Lime is not needed. Soil tests will aid in determining the need for plant nutrients for different crops.

Because it is nearly level, the soil has little water erosion. The surface layers are high in clay and become cloddy if cultivated when wet. A few areas have been flooded frequently and are often too wet for cultivation. They are used for pasture and trees. The upper layers of the soil are slowly permeable, and the lower layers are moderately permeable. If drainage needs to be improved, tile will function fairly well, but suitable outlets may be lacking. They should be placed in the silt loam layer.

Except on areas that are too wet or frequently flooded, this soil is suitable for intensive cropping. It is suited to corn and soybeans. Manure may be needed, and legume-grass meadows should be used and crop residues returned to the soil to maintain favorable tilth. Plowing in fall is best, because the alternate freezing and thawing will aid in forming a more granular structure. This soil is in capability class II, subclass IIw.

Onawa silty clay loam, 0 to 1 percent slopes (Ob).—This nearly level soil occurs in the western part of the county on the flood plain of the Missouri River.

Typical profile:

A_1 0 to 8 inches, very dark grayish-brown (10YR 3/2) silty clay loam; firm when moist; fine granular structure; weakly calcareous.

C 8 to 20 inches, dark-gray to dark grayish-brown (10YR 4/1 to 4/2) silty clay loam; firm when moist; fine granular structure; weakly calcareous.

D 20 to 50 inches, mostly grayish-brown (10YR 5/2) silt loam and thin (¼-to ½-inch) lenses of fine sand and silty clay; a few faint yellowish-brown mottles; strongly calcareous.

VARIATIONS.—In some places the D layer is at a depth of only 15 inches; in other places it is at depths between 35 and 40 inches. In some places the texture of the D layer is fine sand, and in a few places, this layer contains lenses of silty clay loam, apparently a buried former A_1 layer.

Use and management.—This soil is generally low in organic matter and available nitrogen. It is slightly alkaline. Therefore, its supply of available phosphorus is low, but its supply of available potassium is moderately high. Lime is not needed.

Although some areas have been flooded, the soil is usually not too wet for alfalfa and corn. Good tilth is fairly easy to maintain, but the soil tends to clod if plowed when wet or cropped too intensively to corn. The soil is in capability class I.

Salix Soils

The Salix soils occupy areas in the middle and eastern parts of the bottom lands of the Missouri River. Like the Haynie, Luton, Onawa, and Albaton soils, they have formed from sediments deposited by the river. The Salix soils are several centuries older than the Haynie soils. They have developed under prairie vegetation and have a moderately thick, dark-colored surface layer.

Most of the Salix soils are nearly level, but in some of the larger areas, small depressional drainageways occur that were channels cut by floodwaters. The Salix soils have Brunizem profiles.

Salix silt loam, 0 to 1 percent slopes (Sb).—This soil is one of the most productive in Monona County. It is seldom flooded.

Typical profile:

A_1 0 to 14 inches, very dark brown (10YR 2/2) silt loam; friable when moist; fine granular structure; slightly acid.

B_1 14 to 25 inches, dark grayish-brown (10YR 4/2) silt loam with some dark brown (10YR 4/3) in the upper part of the layer; the darker colored material is apparently old worm casts; friable when moist; when digging a larger hole with a spade, there is a tendency for vertical cleavage and for the soil to break into indistinct coarse prismatic pieces; these pieces, when moist, have indistinct subangular blocky and fine granular structure; slightly acid.

B_3 25 to 35 inches, brown (10YR 5/3) silt loam; contains a few faint yellowish-brown mottles; friable when moist; slight tendency to prismatic structure, but structure is indistinct fine granular; slightly acid to nearly neutral.

C 35 to 50 inches, brown (10YR 5/3) silt loam; yellowish-brown mottles are common; friable when moist; a moist piece tends to break into fine granules; there is no definite structure and layer therefore can be said to be massive.

VARIATIONS.—Though calcareous material generally begins below depths of 25 to 30 inches, in some areas it occurs at a depth of 20 inches. In other places there is no calcareous material above 40 inches.

Use and management.—This soil is rarely wet and is seldom flooded. It is not subject to water erosion. Drought is not common. The silt loam surface texture makes good tilth easy to maintain. The soil is moderately high in organic matter and available potassium, but it has only a moderate amount of available phosphorus. Soil tests will help to determine the need for plant nutrients, particularly the need for nitrogen and phosphorus.

The soil is well suited to soybeans and to corn and other row crops. Many different rotations can be used. This soil is in capability class I.

Salix silty clay loam, 0 to 1 percent slopes (Sa).—Like Salix silt loam, 0 to 1 percent slopes, this soil is seldom flooded.

Typical profile:

A_1 0 to 12 inches, black to very dark brown (10YR 2/1 to 2/2) silty clay loam approaching silt loam; firm when moist; fine granular structure; slightly acid; gradual transition to layer below.

B_2 12 to 25 inches, very dark grayish-brown in upper part, grading to dark grayish-brown in lower part (10YR 3/2 to 4/2), silty clay loam approaching silt loam; contains a few faint yellowish-brown mottles in the lower part; firm when moist; distinct fine subangular blocky structure; slightly acid; gradual transition to layer below.

B_3 25 to 35 inches, dark grayish-brown (10YR 4/2) silty clay loam, almost a silt loam; common fine yellowish-brown mottles; firm to friable when moist; indistinct fine subangular blocky structure; slightly acid to neutral.

CD 35 to 50 inches, yellowish-brown (10YR 5/4) silt loam; common strong-brown and olive-gray mottles; friable when moist; structureless; calcareous.

VARIATIONS.—A few areas of Cooper soil are included in this mapping unit. In these places there is a layer of silty clay below depths of 35 to 40 inches. Areas of Salix silty clay loam, 0 to 1 percent slopes, that lie near the Colo and Blencoe soils are generally somewhat wetter than the typical soil. In the narrow, shallow old channels of floodwaters, the A_1 layer is slightly thicker and darker than in the typical soil and slightly more prominent mottling occurs in the B_3 layer.

Use and management.—This soil may clod if plowed too wet. It is seldom flooded. Artificial drainage normally is not needed. Occasionally a few small areas are somewhat wet, and as the subsoil is moderately permeable, tile can be used.

The soil has a moderately large supply of plant nutrients, but soil tests will aid in determining the need for fertilizer. Although the soil is only slightly acid, lime generally is not needed. The soil can be used fairly intensively for row crops. If it becomes cloddy, an extra year of meadow in the crop rotation will help to restore the granular structure. The soil is in capability class I.

Sarpy Soils

The Sarpy soils occupy nearly level to gently sloping areas within a few miles of the Missouri River. Like the Haynie and Albaton soils, they have formed from alluvium deposited during the last few centuries by the Missouri River. Some areas have been frequently flooded in recent years. Some of the sand deposits have been reworked by wind, and in a few places low sand dunes have formed. These soils have Alluvial profiles.

Sarpy fine sandy loam, 0 to 4 percent slopes (Sc).—This is a droughty, moderately coarse textured soil. It is seriously susceptible to wind erosion.

Typical profile:

A_1 0 to 10 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; friable when moist; weak fine granular structure; slightly acid to neutral.

A_3C_1 10 to 20 inches, very dark grayish-brown to dark-gray (10YR 3/2 to 4/1) loamy fine sand; single grain; neutral.

C 20 to 50 inches, dark-gray (10YR 4/1) fine sand; contains a few faint yellowish-brown mottles; single grain; weakly to strongly calcareous.

VARIATIONS.—In a few areas this soil has a very dark brown (10YR 2/2) surface layer. In some places calcareous materials are in the surface layer. In other places they occur at depths of 15 to 20 inches. Small, low, wet areas occur in some places. If these wet areas were larger, they would have been mapped as Onawa or Albaton soils or as Mixed alluvial land.

Use and management.—Because of the sandy surface texture of this soil, wind erosion is often serious. The water-holding capacity is low, and the soil is moderately low to low in plant nutrients, particularly in available nitrogen and phosphorus. Lime is generally not needed. Soil tests can be used as a guide to the need for fertilizers for different crops.

The soil is rather droughty for corn and soybeans, but alfalfa and other deep-rooted legumes usually can obtain moisture from the deep layers. Many areas of this soil are small and are farmed the same as Haynie, Onawa, or other adjacent soils. If corn is grown on the larger areas, a suggested rotation is corn 1 year, oats 1 year, and meadow 2 years. The meadow will help to control wind erosion. Stripcropping and keeping crop residues on the surface will also help. Unless trash is kept on the surface to prevent blowing, this soil should not be plowed in fall.

Water erosion is not a problem, even though some areas have been flooded frequently by the Missouri River. This soil is in capability class III, subclass IIIs.

Sarpy loamy fine sand, 0 to 4 percent slopes (Sd).—Some areas of this droughty, erodible soil have been flooded by the Missouri River.

Typical profile:

A_1 0 to 6 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; single grain; weakly calcareous.

C 6 to 60 inches, dark grayish-brown to grayish-brown (10YR 4/2 to 5/2) fine sand; single grain; slightly calcareous.

VARIATIONS.—Wind erosion has caused mounds that resemble sand dunes to form, and blowouts occur in some areas. In these areas the wind has removed the thin original surface layer. In some places silt or silty clay loam occurs below depths of 3 or 4 feet.

Use and management.—The water-holding capacity of this soil is fairly low, and the soil is rather droughty. When the soil is cultivated, wind erosion is usually severe. The slopes are mild, and water erosion is not a problem, although some areas have been flooded by the Missouri River.

The soil is low in fertility, particularly in available phosphorus and nitrogen. Lime is not needed. Soil tests should be obtained for a guide to the use of fertilizers.

The larger areas of this soil are best suited to trees and pasture. Pastures are susceptible to wind erosion if overgrazed. The smaller areas can be cultivated like the adjoining soils, or if practicable, in a rotation such as corn 1 year, oats 1 year, and meadow 2 years. Alfalfa or other deep-rooted legumes should be seeded in the meadows to utilize the deep subsoil moisture. If plowing is done in fall, trash and stubble left on the surface will reduce erosion by wind and protect the adjacent soils. This soil is in capability class IV, subclass IVs.

Shelby Soils

The Shelby soils occur below the Ida and Monona soils on steep slopes in the uplands. They have formed from glacial till deposited chiefly during the Kansan glacial age. They have developed under prairie grasses, so virgin areas of Shelby soils generally have a moderately thick, dark-colored surface layer. These soils occupy only a small acreage in the county. Many areas include Monona and Ida soils, which were derived from loess.

Some small areas of Steinauer soils are also included.

In many places narrow bands of Adair soils are mapped with the Shelby soils, and in some places Malvern soils are included in the mapping unit. The Adair soils have a clay subsoil that is very slowly permeable to water. On sidehill seepage areas, the Adair or Malvern soils commonly occur next to loess and seep-line areas. They occupy areas that are too small to map separately. The Adair soils generally occur close to the border of the Shelby soils, near the areas of included Ida and Monona soils. They have formed from Kansan glacial till. The Malvern soils have formed from Loveland loess that was deposited at the time of the Illinoian glacial age. The Shelby soils have Brunizem profiles.

Shelby loam, 8 to 14 percent slopes (Se).—This soil has formed from glacial till on the lower slopes of the uplands.

Typical profile:

A_p 0 to 4 inches, very dark grayish-brown (10YR 3/2) loam that approaches a clay loam; friable to slightly firm when moist; fine granular structure; slightly acid.

A_3 4 to 10 inches, dark grayish-brown and some dark-brown (10YR 4/2 and 4/3) clay loam that approaches a loam; contains some coarse gravel and small stones; firm when moist; distinct fine subangular blocky structure; slightly acid.

B_2 10 to 18 inches, dark-brown (10YR 4/3) clay loam; contains some coarse gravel and small stones; firm when moist; distinct fine subangular blocky structure; slightly acid.

B_3 18 to 30 inches, dark-brown (10YR 4/3) clay loam that approaches a loam; a few faint yellowish-brown mottles; contains coarse gravel and small stones; firm when moist; indistinct medium subangular blocky structure; slightly acid to nearly neutral.

C 30 to 50 inches, yellowish-brown (10YR 5/4) clay loam that approaches a loam; common strong-brown mottles; some coarse gravel and small stones; slightly firm to firm when moist; indistinct coarse blocky structure; calcareous; contains thin bands of calcium carbonate.

VARIATIONS.—Depth to calcareous materials ranges from between 10 and 15 inches to between 36 and 50 inches. In many places the surface texture in eroded areas is clay loam.

Use and management.—The slopes and somewhat slow permeability of the subsoil and substratum cause serious water erosion. The soil is only moderately fertile. The content of organic matter is generally low, especially in areas that have lost the surface layer through erosion. Lime may be needed to correct acidity. Soil tests will aid in determining the fertilizer needs for different crops.

Grain crops do not yield well on this soil. Most areas of the soil are small and, in many places, are used in the same way as adjacent areas. If the soil is cultivated, corn should not be grown more than once in 4 or 5 years. A suitable rotation would be corn 1 year, oats 1 year, and meadow 2 years, with all cultivation on the contour. The lower layers are too slowly permeable for level terraces and contour listing to be used. This soil is in capability class IV, subclass IVe.

Shelby loam, 14 to 35 percent slopes (Sg).—Except for stronger slopes, this soil resembles Shelby loam, 8 to 14 percent slopes.

VARIATIONS.—This soil has the same variations as Shelby loam, 8 to 14 percent slopes.

Use and management.—Generally, organic matter is low in this soil. Lime is needed in some areas to correct acidity. Because of steeper slopes, erosion is a more serious problem than on Shelby loam, 8 to 14 percent slopes. This soil should be used only for permanent pasture. It is in capability class VI, subclass VIe.

Steinauer Soils

The Steinauer soils occur in the upland part of the county. Generally they occur on slopes below the Hamburg, Ida, Castana, and Monona soils. Most areas have slopes greater than 15 percent. The soils were formed from glacial till. Areas that have not been disturbed by cultivation have a moderately dark surface layer. Some of the same soils included within areas of the Shelby soils are also mapped with the Steinauer soils. The Steinauer soils have Regosol profiles.

Steinauer loam, 8 to 35 percent slopes (Sh).—This loamy soil occurs on slopes in the eastern part of the county.

Typical profile of virgin soil:

A_1 0 to 6 inches, very dark gray (10YR 3/1) loam that approaches a clay loam; friable to slightly firm when moist; fine granular structure; strongly calcareous.

C 6 to 50 inches, yellowish-brown (10YR 5/4) clay loam; common strong-brown mottles; contains fine gravel; alkaline, with seams and streams of calcium carbonate.

VARIATIONS.—Most of the cultivated areas of Steinauer soils have lost the original thin dark surface layer. Slopes range from 8 to 35 percent, but most slopes are greater than 15 percent. In a few places, the lower layer of clay loam has pockets of sand and gravel.

Use and management.—This soil is somewhat low in plant nutrients. Available phosphorus is particularly low, because the surface layer is calcareous. The soil has excess lime in the surface layer, so lime should not be applied. Soil tests will aid in determining the fertilizer needs for different crops.

When the soil is cultivated, it is very erodible. Therefore, most areas should be used for permanent pasture. On many of the smaller areas, where the slopes are less than 15 percent, corn can be grown once in every 4 or 5 years. In general, cultivation should be on the contour, but it is best not to use level terraces and contour listing, because of the somewhat slow permeability of the subsoil. This soil is in capability class VI, subclass VIe.

Steinauer-Castana complex, 8 to 30 percent slopes (Sk).—This complex includes areas of the Steinauer and Castana soils that were too small to map separately. Most of the soils occur on west-facing slopes of the first bluffs in the eastern part of the Missouri River bottoms. As a rule they occur on slopes of 15 to 25 percent. Their profiles resemble those described for Steinauer loam, 8 to 35 percent slopes, and Castana silt loam, 8 to 14 percent slopes.

VARIATIONS.—The variations are the same as those given for the Steinauer series and the Castana series.

Use and management.—The Castana part of the complex is somewhat more fertile than the Steinauer. Soil tests can be used as a guide in applying fertilizer for different crops. Erosion is serious when the soils are cultivated. The steeper slopes should be used only for permanent pasture. Areas of the Steinauer-Castana complex that have slopes of more than 15 percent should not be cropped to corn. On lesser slopes corn can be grown in a rotation with 1 year of oats and 2 years of meadow.

It is best to cultivate on the contour, but because of the somewhat slow permeability of the subsoils, level terraces and contour listing are not generally practicable. The complex is in capability class IV, subclass IVe.

Zook Soils

The Zook soils occupy nearly level areas and depressions, which in some places were old stream channels. They occur along the rivers that flow from the uplands onto the eastern edge of the Missouri River bottom lands. They are largely in association 3, particularly where associations 2 and 3 lie next to each other. Some of the soils are along the Soldier River in associations 4 and 5. They have formed from sediments deposited by the Maple, Soldier, and Little Sioux Rivers and possibly by the Missouri River. Most of the sediments were laid down before the county was cultivated, but apparently some are fairly recent. The Zook soils are associated with the Colo silty clay loams and Luton clays. They generally contain less clay than the Luton clays but more than the Colo silty clay loams. The Zook soils have Humic Gley (Wiesenboden) profiles.

Zook silty clay, 0 to 1 percent slopes (Za).—This is a wet soil. Some areas have been frequently flooded.

Typical profile:

A_1 0 to 15 inches, black (10YR 2/1) silty clay that approaches a silty clay loam; firm when moist; indistinct fine subangular blocky structure; slightly acid.

B_1 15 to 36 inches, black (10YR 2/1) silty clay that approaches a silty clay loam; firm when moist; indistinct fine subangular blocky structure; slightly acid.

D 36 to 50 inches, very dark grayish-brown (10YR 3/2) silty clay; faint yellowish-brown mottles; firm to very firm when moist; indistinct medium blocky structure; slightly acid.

VARIATIONS.—In a few places, the texture is silty clay loam, and in others it is clay at depths of 20 to 40 inches. Evidence of a buried surface layer of silty clay occurs in some areas below depths of 30 to 35 inches.

Use and management.—The chief problems in managing this soil are protecting the areas from flooding and removing excess surface water. Because of the somewhat slowly permeable subsoil, tile does not function well. Outlets are poor for either tile or surface drains, but if outlets are available, surface ditches can be used to remove excess surface water. Dikes will protect some areas from flooding, though they break sometimes and intensify the flood problem.

Wetness in spring often delays planting. If the soil is plowed when too wet, the surface layer puddles and clods. Fall plowing is better. Returning crop residues, adding manure, and growing grass-legume meadow will aid in maintaining a granular tilth.

This soil is frequently too wet for corn and alfalfa, and it is frequently too wet in spring for any planting. Where the lower part of the profile is clay, the permeability is somewhat slow to very slow. The wetter areas can be planted to winter wheat when the soil is dry. Corn and soybeans are grown on areas that are not so wet nor so subject to flooding.

Although this silty clay has a high content of organic matter, available nitrogen and phosphorus are commonly low because the soil is often cold and wet early in spring. Soil tests should be made before determining the fertilizer needs for different crops. This soil is in capability class III, subclass IIIw.

Zook silty clay, calcareous variant, 0 to 1 percent slopes (Zb).—This soil occurs in the eastern part of the Missouri River bottom lands. It is calcareous throughout. Because of its limited extent in Monona County and its possibly greater extent in Woodbury County, the final naming of this soil has been deferred and it was included in the Zook series.

Except that it is calcareous, the profile is similar to that of Zook silty clay, 0 to 1 percent slopes, in color, texture, and consistence.

Use and management.—This soil has a slowly permeable subsoil, and wetness is a fairly severe problem. If the soil is plowed when too wet, the surface structure becomes cloddy. Granular tilth should be maintained by returning crop residues, applying manure, and growing legume-grass meadow. Because of the wet calcareous surface layer, available phosphorus and potassium are usually low. Drainage needs improvement, but tile drains do not function well. The soil is in capability class III, subclass IIIw.

Productivity, Management, and Capability

In Monona County there are 51 soils and miscellaneous land types. In the following section, their productivity, management, and capability are discussed.

The section is divided into three parts. The first gives estimated average acre yields of corn on each of the soils under ordinary management and estimated average acre yields of corn, oats, soybeans, and hay under improved management. The second describes various characteristics of each soil that affect yields and management. The third defines the capability classes and indicates the capability class and subclass of each soil in the county.

Estimated Yields and General Requirements for Management

Table 5 lists the soils of Monona County and gives the estimated average acre yields of corn on each soil along with the factors that limit the yields. It also indicates the management practices that should be used to obtain high yields and gives estimated average acre yields of corn, oats, soybeans, and hay that can be sustained at high levels of fertility.

High yields cannot be obtained always, even with good management and an adequate supply of plant nutrients. On Luton clay, 0 to 1 percent slopes, for example, the estimated attainable sustained average yield of corn per acre indicated in table 5 is 45 bushels, even though the soil may contain enough plant nutrients for much higher yields and may be well managed. This is because the soil is so wet and fine textured that proper cultivation is difficult and drainage cannot always be improved adequately.

TABLE 5.—*Estimated average acre yields of principal crops to be expected for the various soils under two levels of management*

Map symbol	Soil	Estimated average yield of corn per acre under present practices	Fertilizer elements other than nitrogen [1] most likely to be deficient, and other factors that limit yields	Estimated average yields per acre under improved management [2]				Major practices needed, besides fertility programs [3]
				Corn	Oats	Soybeans	Hay [4]	
		Bu.		*Bu.*	*Bu.*	*Bu.*	*Tons*	
Aa	Albaton clay, 0 to 1 percent slopes.	40	Phosphorus; tilth, wetness.	50	32	22	2.2	Tilth maintenance, drainage improvement.
Ba	Blencoe silty clay, 0 to 1 percent slopes.	44	Same	56	36	24	2.2	Tilth maintenance, drainage improvement.
Bb	Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes.	42	Same	54	36	24	2.2	Tilth maintenance, drainage improvement.
Ca	Castana silt loam, 8 to 14 percent slopes.	39	Erosion, moisture deficiency.	60	42	------	2.2	Contouring, terraces; CCOM [5] rotation.
Cb	Castana silt loam, 14 to 22 percent slopes.	31	Same	50	32	------	2.0	Contouring, terraces;[6] COMM rotation.
Cc	Castana silt loam, 22 to 30 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 85	Permanent vegetation.
Cd	Colo silty clay loam, 0 to 1 percent slopes.	44	Tilth, wetness	66	52	29	2.4	Tilth maintenance, drainage improvement.
Ce	Colo silty clay loam, moderately shallow over silt loam, 0 to 1 percent slopes.	48	Tilth, wetness	68	53	29	2.6	Tilth maintenance, drainage improvement.
Cg	Colo silty clay loam, calcareous variant, 0 to 1 percent slopes.	42	Phosphorus; potassium, tilth, wetness.	65	51	28	2.4	Tilth maintenance, drainage improvement.
Ch	Cooper silty clay loam, 0 to 1 percent slopes.	53	Phosphorus	68	53	30	3.2	Tilth maintenance, drainage improvement.
Ha	Hamburg silt loam, 30 to 60 percent slopes.	(7)	Very steep slopes	(7)	(7)	(7)	[8] 40	Grazing restriction, permanent vegetation.
Hd	Haynie silt loam, 0 to 1 percent slopes.	35	Phosphorus; some flooding.	65	48	28	2.8	Flood prevention.
Hb	Haynie fine sandy loam, 0 to 1 percent slopes.	30	Phosphorus; some flooding.	55	36	20	2.2	Flood prevention, wind-erosion control.
Hc	Haynie loamy fine sand, 0 to 2 percent slopes.	30	Phosphorus; moisture deficiency.	48	30	16	1.8	Flood prevention, wind-erosion control.
Ia	Ida silt loam, 1 to 7 percent slopes.	20	Phosphorus; erosion, moisture deficiency.	54	35	------	2.2	Contouring, terraces; CCOM rotation.
Ib	Ida silt loam, 7 to 14 percent slopes.	16	Same	51	32	------	2.2	Contouring, terraces; CCOM rotation.
Ic	Ida silt loam, 14 to 22 percent slopes.	13	Same	38	24	------	1.8	Contouring, terraces;[6] COMM rotation.
Id	Ida silt loam, 22 to 30 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 60	Permanent vegetation.
Ie	Ida silt loam, 30 to 50 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 50	Permanent vegetation, grazing restriction.
Ka	Kennebec silt loam, 0 to 1 percent slopes.	53	Flooding	68	53	30	3.2	Flood prevention, artificial drainage.
Kb	Kennebec silt loam, calcareous variant, 0 to 1 percent slopes.	40	Phosphorus, potassium; flooding.	66	52	28	2.8	Flood prevention, artificial drainage.
La	Luton clay, 0 to 1 percent slopes.	38	Phosphorus, wetness	45	30	22	1.6	Tilth maintenance, drainage improvement.
Lb	Luton clay, overwash phase, 0 to 1 percent slopes.	40	Phosphorus, wetness	47	32	23	1.8	Tilth maintenance, drainage improvement.
Lc	Luton silty clay, moderately shallow over silty clay loam, 0 to 1 percent slopes.	40	Phosphorus, wetness	50	32	22	2.2	Tilth maintenance, drainage improvement.
Ma	McPaul silt loam, 0 to 2 percent slopes.	44	Flooding	64	44	27	2.4	Flood prevention, artificial drainage.
Mb	Mixed alluvial land	(9)	Phosphorus; flooding	(9)	------	------	------	------
Mc	Modale silt loam, 0 to 1 percent slopes.	39	Phosphorus; flooding	60	42	25	2.4	Flood prevention.
Md	Modale sandy loam, 0 to 1 percent slopes.	32	Phosphorus; flooding	52	34	20	2.2	Flood prevention.
Me	Monona silt loam, 1 to 7 percent slopes.	45	Phosphorus, erosion, moisture deficiency.	65	44	27	2.4	Contouring, terraces, CCOM rotation.

See footnotes at end of table.

TABLE 5.—*Estimated average acre yields of principal crops to be expected for the various soils under two levels of management*—Continued

Map symbol	Soil	Estimated average yield of corn per acre under present practices	Fertilizer elements other than nitrogen [1] most likely to be deficient, and other factors that limit yields	Estimated average yields per acre under improved management [2]				Major practices needed, besides fertility programs [3]
				Corn	Oats	Soybeans	Hay [4]	
		Bu.		*Bu.*	*Bu.*	*Bu.*	*Tons*	
Mg	Monona silt loam, 1 to 7 percent slopes, eroded.	41	Same	62	42	25	2. 4	Contouring, terraces, CCOM rotation.
Mh	Monona silt loam, 7 to 14 percent slopes.	39	Same	60	42		2. 2	Contouring, terraces, CCOM rotation.
Mk	Monona silt loam, 7 to 14 percent slopes, eroded.	36	Same	54	36		2. 2	Contouring, terraces, CCOM rotation.
Mm	Monona silt loam, 14 to 22 percent slopes.	31	Same	50	32		2. 0	Contouring, terraces;[6] COMM rotation.
Mn	Monona silt loam, 14 to 22 percent slopes, eroded.	24	Same	44	30		1. 8	Contouring, terraces;[6] COMM rotation.
Mo	Monona silt loam, 22 to 30 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 80	Permanent vegetation.
Mp	Monona silt loam, 22 to 30 percent slopes, eroded.	(7)	Same	(7)	(7)	(7)	[8] 80	Permanent vegetation.
Mr	Monona silt loam, 30 to 40 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 60	Permanent vegetation, grazing restriction.
Na	Napa clay, 0 to 1 percent slopes.	10	Tilth, wetness	10	15	5	. 5	Drainage improvement.
Nb	Napier silt loam, 4 to 10 percent slopes.	54	Gully erosion	70	54	30	3. 2	Contouring where sloping, grassed waterways where needed; CCOM rotation.
Oa	Onawa silty clay, 0 to 1 percent slopes.	40	Phosphorus; tilth, wetness.	54	34	24	2. 2	Flood prevention, tilth maintenance.
Ob	Onawa silty clay loam, 0 to 1 percent slopes.	50	Phosphorus	65	50	28	3. 0	Flood prevention, tilth maintenance.
Sb	Salix silt loam, 0 to 1 percent slopes.	55	Phosphorus	72	55	30	3. 2	CCOM rotation.
Sa	Salix silty clay loam, 0 to 1 percent slopes.	54	Phosphorus	70	54	30	3. 2	CCOM rotation.
Sc	Sarpy fine sandy loam, 0 to 4 percent slopes.	20	Phosphorus; wind erosion, moisture deficiency.	40	26	12	1. 5	Wind erosion control; COMM rotation.
Sd	Sarpy loamy fine sand, 0 to 4 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 50	Permanent vegetation.
Se	Shelby loam, 8 to 14 percent slopes.	25	Phosphorus, erosion, moisture deficiency.	45	32		1. 8	Contouring, terraces; CCOM rotation.
Sg	Shelby loam, 14 to 35 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 60	Permanent vegetation.
Sh	Steinauer loam, 8 to 35 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 60	Permanent vegetation.
Sk	Steinauer-Castana complex, 8 to 30 percent slopes.	(7)	Same	(7)	(7)	(7)	[8] 60	Permanent vegetation.
Za	Zook silty clay, 0 to 1 percent slopes.	44	Phosphorus, wetness	54	36	24	2. 2	Flood prevention, drainage improvement.
Zb	Zook silty clay, calcareous variant, 0 to 1 percent slopes.	40	Phosphorus, potassium, wetness.	47	32	23	1. 8	Flood prevention, drainage improvement.

[1] Nitrogen levels vary considerably with past management.
[2] These long-time average yields are attainable with present known techniques and seed varieties (1955) and with average weather conditions. It is assumed that phosphorus and potassium fertilizers and lime are added as needed based on soil tests; nitrogen fertilizer is added as indicated by soil tests and cropping history; and that flooding is controlled.
[3] The yields, in most cases, could be obtained by several different combinations of soil treatments and rotation practices; practices will control erosion to the extent of about 5 tons of soil loss per acre per year.
[4] Assumed to be chiefly brome-alfalfa.
[5] C=Corn; O=Oats; M=Meadow in a rotation.
[6] The steeper slopes in this group may be too steep for use of terraces.
[7] Best suited to permanent vegetation.
[8] Estimated number of days 1 acre will carry 1 cow.
[9] Yields highly variable on Mixed alluvial land.

Soil Characteristics and Management That Affect Yields

The yields that are produced on a soil are determined by its characteristics and the management applied. In Monona County the characteristics of the soils differ to the extent that yields are much higher on some soils than on others. On some soils such as the Sarpy, yields are low because the soils are droughty; on soils such as the Luton, yields are low because the soils are often wet.

The management practices applied—listing and planting on the contour; using terraces, grassed waterways, and planting trees; stripcropping or using buffer strips; building small dams; and using more definite crop rotations—have six purposes (*11*). All of the first five purposes, and to some extent the sixth, are affected by the characteristics of the soil. These purposes are—

1. To provide means for better infiltration of rainfall into the soil.
2. To provide better ways of removing surplus water and directing it into streams without excessive loss of soil.
3. To maintain a favorable structure and fertility level.
4. To prevent the formation of gullies so that farming can readily be carried on with mechanized equipment.
5. To include methods that permit as large an acreage of corn as is consistent with the goals for erosion control and maximum total production.
6. To include practices that are within the skill and financial ability of most farmers.

Texture

One of the important properties that affects yields and management is texture. Soils that have a sandy texture, such as the Sarpy soils, are droughty because they can hold little water. Soils that have a clay texture, such as the Albaton and Luton, are often too wet because water moves slowly through the profile.

The texture of the surface layer is important in maintaining good tilth. In the sloping soils that have a high content of silt in the surface layer, such as the more sloping Ida soils, a granular structure is difficult to maintain. Because of their strong slopes, these soils lose soil and water unless special precautions are taken. A granular structure is more readily maintained in the nearly level soils that have a silt loam surface layer, as in the Haynie, Kennebec, and Salix silt loams, than in the finer textured clay soils. In soils that have a clay surface layer, such as the Albaton and Luton, a granular structure is seldom achieved. Nevertheless, available crop residues and manure should be turned under to make the structure as nearly granular as possible and to improve tilth.

Organic matter

A characteristic that affects the use, capability, productivity, and management of a soil is the amount of organic matter it has in the plow layer. Organic matter improves the structure, helps the soil retain moisture and plant nutrients, and improves tilth. It can be added to the soil by plowing under manure or residues of crops.

Soil porosity and permeability

Wet soils contain little air. The soil is made up principally of water and soil particles. Most of the soils in the county, if completely saturated, would be comprised of about one-half solids (or mineral materials) and about one-half water. The water is held in the spaces, or pores, between the solids. These pores are of different sizes in different soils. If the pores are small, as they are in the lower part of the Luton profiles, water moves through the soil slowly and drainage is not improved to any extent by tiling. In the lower part of the Monona profiles, the pores are larger and water moves fairly rapidly through the soil. Thus, contour cultivation and level terraces are successful in conserving water and soil, because they cause the water to pass into and through the permeable lower layers.

The permeability of the soils to water is discussed in the descriptions of the individual soils. It is important to consider permeability in removing excess water from wet soils. It is also an important consideration in controlling erosion. For example, by using level terraces and contour listing on the less strongly sloping Monona soils, water can be conserved and made to pass into and through the permeable lower layers. On the Shelby soils, however, contour listing and level terracing should not be used, as water moves into and through the slowly permeable lower layers so slowly that ponding may occur in the lister furrows and terrace channels.

Erosion under cultivation

If soils that have strong slopes are cultivated, management practices are needed that will reduce the loss of soil and water, maintain fertility, and keep gullies from forming. According to the Iowa Agricultural Experiment Station, one of the principal goals of soil use should be to hold soil loss to no more than 5 tons per acre annually to maintain soil fertility and prevent gullies from forming. During the years 1948 to 1954, inclusive, experiments were conducted at the Castana Experimental Farm to evaluate the effectiveness of using contouring and crop rotations in reducing losses of soil and water. The results are shown in table 6.

The experiments were conducted on areas of Ida silt loam that had 14 percent slopes. The length of the slopes used for the experiments was 72.6 feet, and the width of the plot was 10.5 feet. The results showed that the greatest loss of soil and water occurred when corn was surface planted with the slope. Surface planting on the contour reduced the losses of soil and water appreciably, but listing on the contour was even more effective. Losses of soil and water on areas under meadow were low.

Soil aeration and drainage

The average rainfall is nearly uniform throughout the county. The soils vary, however, in the length of time they remain saturated after moderate to heavy rains. Plants such as corn and alfalfa do not grow well if the

TABLE 6.—*Effect of tillage and cropping practices in reducing losses of soil and water on areas of Ida silt loam that have slopes of 14 percent*

Cropping system and tillage treatment	Soil loss per acre	Runoff
UNDER CORN		
	Tons	*Inches*
Corn-oats (sweetclover catch crop):		
Surface planted with the slope	26. 1	3. 47
Surface planted on the contour	9. 8	2. 20
Listed on the contour	2. 6	1. 30
Corn-oats-meadow-meadow:		
Listed on the contour	1. 4	. 70
UNDER OATS		
Corn-oats (sweetclover catch crop)	2. 3	2. 14
Corn-oats-meadow-meadow	2. 0	1. 38
UNDER MEADOW		
First-year meadow in a corn-oats-meadow-meadow rotation	. 29	. 70
Second-year meadow in a corn-oats-meadow-meadow rotation	. 04	. 51

soil is too wet. On many soils of the county, drainage or the protection of the soils from flooding requires continuing attention.

The Monona soils and Salix silt loam, 0 to 1 percent slopes, are seldom too wet for corn and alfalfa, but in many years the Luton soils are too wet for corn. Other soils such as Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes, occasionally may be too wet.

In making a soil survey, it is not feasible to obtain information on the problem of wetness or flooding on individual fields. The farmer must determine the kind of soils in each of his fields and study the soil profiles in each so that he can tell what is needed to drain the soils or to protect them from floods. Often roads or dikes and ditches are constructed so that one field is protected, but an adjacent field is still subject to flooding or is too wet. Farmers or others interested in purchasing or renting bottom-land farms should obtain from neighbors as much local information as possible about the flood hazard or need for drainage.

Soil tilth and structure

Tilth, or ease of tillage, depends on several soil properties. Permeability, content of organic matter, texture, compaction, and soil aggregation, or structure, are all important. Texture is perhaps the most important. Sandy soils are commonly called "light" soils because they are easy to till, and a clay soil is called "heavy" because it is difficult to till.

Differences in soil structure also greatly affect the tilth of the soil. In general, the best way to maintain or improve structure is to (1) seed the soils to meadow or sod, (2) plow under organic residues, and (3) protect the soils from trampling when they are wet. Soils high in organic matter generally have a much more desirable structure than do soils of similar texture that contain little organic matter.

Differences in soil structure are of less importance to crop production on sandy soils than on some of the finer textured soils. Even with very poor structure, the sandy soils will be easy to till. Soil structure is also of less importance in the silt loams and loams than in some of the finer textured soils. On the finer textured soils, the maintenance of structure becomes a much more important management problem. If Luton clay, 0 to 1 percent slopes, for example, is cultivated when wet, it may dry in such large and hard clods that a seedbed cannot be prepared until the following year. Keeping meadow and sod crops on the soils and adding organic matter are helpful in maintaining a desirable soil structure on the fine-textured soils. When these fine-textured soils are used for grain, turning under crop residues is of some value.

The small areas of Napa soil, called "slick spots" or "alkali spots," have the poorest soil structure of any of the soils in the county. Regardless of moisture or management, the structure is unfavorable for plant growth, and no practical means of improving it in these soils has been found.

Need for amendments

Although the soils in two fields may be similar, they may differ in fertility. This is to be expected as the soils may have been managed differently in the past. To assess the fertility level, and to help in choosing the kinds and amounts of fertilizers, soil tests should be made. The Soil Testing Laboratory of Iowa State College will analyze soil samples for farmers at their request. Information about sampling methods can be obtained from the county extension director.

From the results of field experiments on the fertilizer needs of a number of Monona County soils, it is evident that there are some rather extreme differences in the fertility of Monona County soils. The Ida soils, for example, are commonly very deficient in available phosphorus. In general, soils that have a calcareous surface layer are likely to be low in available phosphorus. Many of the soils, particularly those derived from loess, are moderately high in available potassium.

Some of the nearly level areas of Monona soils, especially Monona silt loam, 1 to 7 percent slopes, and Monona silt loam, 1 to 7 percent slopes, eroded, may require small amounts of lime to correct acidity. Most of the soils of the county, however, are neutral to alkaline in reaction. In fact, a number of soils, such as the Ida, Haynie, and Modale, have excess lime, which is the principal cause of their low supply of available phosphorus.

Capability of Monona County Soils

The capability classification is a means of showing the comparative suitability of different soils for agricultural uses. The classification of a particular soil depends on the variety of uses to which it is suited, its susceptibility to erosion or other damage if it is cultivated, and the kind of management it needs to protect it from erosion and maintain its productivity.

Eight general capability classes are recognized. In classes I, II, and III are soils that are suitable for annual or periodic cultivation. Class I soils are those that have the widest range of use. They are level, productive, well drained, and easy to work. The soils do not require tile drainage for good crop yields. They do not erode readily, even if cultivated continuously, and will remain productive if managed with normal care. Class II soils do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping and consequently need moderate care to prevent erosion; others may be slightly droughty or slightly too wet, or somewhat limited in depth. Class III soils can be cropped regularly but have a narrower range of use and need still more careful management.

In class IV are soils that should be cultivated only occasionally or only under very careful management.

In classes V, VI, and VII are soils that are not well suited to cultivation but that can be used for pasture, for range, or for forest. Class V soils are level but are droughty, wet, or low in fertility, or otherwise unsuitable for cultivation. Class VI soils are not suitable for crops, because they are steep or droughty or otherwise limited, but they give fair yields of forage or forest products. Some soils in class VI can be cultivated enough without damage so that trees can be set out or pasture plants seeded. Class VII soils provide only poor to fair yields of forage or forest products.

In class VIII are soils that have practically no agricultural use. These areas produce little useful vegetation, but they may constitute attractive scenery; they may form parts of watersheds; or they may provide shelter for wildlife. Some areas have been developed into recreational sites. Mountains, deserts, and sand dunes are examples of class VIII land.

The soils in any one capability class are limited to the same degree but may be limited for different reasons. To show what characteristic of each soil limits its uses, any one of classes II through VII may be divided into from 1 to 4 subclasses, each identified by a letter following the capability class number. The letter "e" indicates that risk of erosion is what limits the uses of the soil; the letter "w" is used if the soil is limited by excess water; the letter "s" shows that the soil is shallow, droughty, or unusually low in fertility; and the letter "c" is used to indicate that the climate is so hazardous that it limits the uses of the soil. Climate generally is not considered a limiting factor in Monona County.

CLASSES AND SUBCLASSES IN MONONA COUNTY

The soils of Monona County have been placed in capability classes I, II, III, IV, V, VI, and VII. None of the soils of the county have been placed in class VIII. The definitions of each class and subclass and the class and subclass for each soil in the county follow:

Class I. Thick, well drained and moderately well drained, nearly level soils; suited to intensive cultivation (also suited to pasture, trees, and wildlife) over long periods without special practices other than those generally used for good farming.
  The mapping units are—
    Hd Haynie silt loam, 0 to 1 percent slopes.
    Ka Kennebec silt loam, 0 to 1 percent slopes.
    Ma McPaul silt loam, 0 to 2 percent slopes.
    Mc Modale silt loam, 0 to 1 percent slopes.
    Ob Onawa silty clay loam, 0 to 1 percent slopes.
    Sa Salix silty clay loam, 0 to 1 percent slopes.
    Sb Salix silt loam, 0 to 1 percent slopes.

Class II. Soils that can be cultivated with only moderate risks of erosion or that have other moderate limitations.
  IIe. Soils subject to erosion—
    Subject mainly to sheet erosion—
      Me Monona silt loam, 1 to 7 percent slopes.
      Mg Monona silt loam, 1 to 7 percent slopes, eroded.
  IIw. Soils affected by excess water—
    Mainly because of imperfect to poor drainage—
      Ba Blencoe silty clay, 0 to 1 percent slopes.
      Bb Blencoe silty clay, clayey substratum variant, 0 to 1 percent slopes.
      Cd Colo silty clay loam, 0 to 1 percent slopes.
      Ce Colo silty clay loam, moderately shallow over silt loam, 0 to 1 percent slopes.
      Cg Colo silty clay loam, calcareous variant, 0 to 1 percent slopes.
      Ch Cooper silty clay loam, 0 to 1 percent slopes.
      Kb Kennebec silt loam, calcareous variant, 0 to 1 percent slopes.
      Oa Onawa silty clay, 0 to 1 percent slopes.
  IIs. Soils limited mainly by features other than erosion or excess water—
    Droughty soils—
      Md Modale sandy loam, 0 to 1 percent slopes.

Class III. Soils that can be used for tilled crops with moderately severe risks of erosion or other moderately severe limitations.
  IIIe. Soils subject to erosion—
      Ca Castana silt loam, 8 to 14 percent slopes.
      Ia Ida silt loam, 1 to 7 percent slopes.
      Ib Ida silt loam, 7 to 14 percent slopes.
      Mh Monona silt loam, 7 to 14 percent slopes.
      Mk Monona silt loam, 7 to 14 percent slopes, eroded.
    Subject to gully erosion—
      Nb Napier silt loam, 4 to 10 percent slopes.
  IIIw. Soils affected by excess water—
    Mainly because of imperfect to poor drainage and poor tilth—
      Aa Albaton clay, 0 to 1 percent slopes.
      La Luton clay, 0 to 1 percent slopes.
      Lb Luton clay, overwash phase, 0 to 1 percent slopes.
      Lc Luton silty clay, moderately shallow over silty clay loam, 0 to 1 percent slopes.
      Za Zook silty clay, 0 to 1 percent slopes.
      Zb Zook silty clay, calcareous variant, 0 to 1 percent slopes.
  IIIs. Soils limited mainly by features other than erosion or wetness—
    Droughty soils—
      Hb Haynie fine sandy loam, 0 to 1 percent slopes.
      Hc Haynie loamy fine sand, 0 to 2 percent slopes.
      Sc Sarpy fine sandy loam, 0 to 4 percent slopes.

Class IV. Soils severely limited or subject to high risks of soil damage when used for cultivation. Can be cultivated with special management.

IVe. Soils subject to erosion—
Mainly sheet erosion with some gully erosion—
Cb Castana silt loam, 14 to 22 percent slopes.
Ic Ida silt loam, 14 to 22 percent slopes.
Mm Monona silt loam, 14 to 22 percent slopes.
Mn Monona silt loam, 14 to 22 percent slopes, eroded.
Se Shelby loam, 8 to 14 percent slopes.
Sk Steinauer-Castana complex, 8 to 30 percent slopes.

IVw. Poorly drained black alkali soils that have poor tilth—
Na Napa clay, 0 to 1 percent slopes.

IVs. Soils limited mainly by features other than erosion and wetness—
Droughty soils—
Sd Sarpy loamy fine sand, 0 to 4 percent slopes.

Class V. Soils unsuited to cultivation because of excess water. Few limitations for grazing or forestry.
Vw. Soils subject to frequent flooding—
Mb Mixed alluvial land.

Class VI. Soils unsuited to cultivation, except for the minimum required to establish pasture, forage, or trees, because of erosion or other limitations.
VIe. Soils subject to erosion—
Cc Castana silt loam, 22 to 30 percent slopes.
Id Ida silt loam, 22 to 30 percent slopes.
Mo Monona silt loam, 22 to 30 percent slopes.
Mp Monona silt loam, 22 to 30 percent slopes, eroded.
Sg Shelby loam, 14 to 35 percent slopes.
Sh Steinauer loam, 8 to 35 percent slopes.

Class VII. Soils unsuited to cultivation and unless properly managed subject to serious limitations or soil damage when used for pasture or as woodland.
VIIe. Soils subject to erosion—
Ha Hamburg silt loam, 30 to 60 percent slopes.
Ie Ida silt loam, 30 to 50 percent slopes.
Mr Monona silt loam, 30 to 40 percent slopes.

Formation and Classification of Soils

This section consists of two main parts. The first discusses the factors of soil formation as they relate to the development of soils in Monona County. In the second part, the soil series are placed in great soil groups and families and these higher categories are defined.

Formation of Soils

The factors that have caused differences among the soils of Monona County are the parent material, vegetation, relief and natural drainage, climate, and the length of time the soils have weathered. One of the most important of these factors is the parent material.

Parent materials

The soils of Monona County were derived from three kinds of parent material—loess, alluvium, and glacial till. Of these, the soils derived from loess are the most extensive.

Loess was the parent material of the Hamburg, Ida, and Monona soils. It is of Wisconsin age, according to Ruhe and Scholtes (*6*).[3] It is as much as 80 to 100 feet thick in some places in the county. Where it is calcareous, it is fairly high in silt and contains almost no sand-sized particles.

According to Shimek (*7*), the Wisconsin loess overlies Loveland material in Monona County. Kay and Graham (*4*) believed the Loveland material to be loess of immediate post-Illinoian age. The Loveland material has not been a major soil-forming material in this county. It was, however, the parent material of areas of Malvern soils, which are not mapped separately in this county but are included in areas of Shelby soils. According to Kay and Graham (*4*), Kansan glacial till underlies Loveland loess in Monona County. The Shelby and Steinauer soils have formed in this till. The Adair soils have also formed in this till but in an earlier geologic time than the Shelby and Steinauer soils (*6*).

Alluvium was the parent material of many of the soils of the county. The alluvium in this county varies more in texture and color than either the loess or the glacial till. It apparently differs in age, as will be explained under the heading, Time.

The soils derived from glacial till occupy only a small acreage. Where the glacial till is exposed, it is calcareous clay loam that contains some pebbles and a few boulders. Although the mineral content of the unleached glacial till or the Wisconsin loess in this county has not been determined, samples of loess taken in other parts of Iowa contain many different minerals (*4*).

Vegetation

After the soil material was deposited—loess, alluvium, or glacial till—bacteria, fungi, and other simple forms of life invaded it. Later, prairie grasses, the main vegetation in this county, became established. Each year the grasses developed new growth above ground and their extensive fibrous root systems grew in the upper few feet of the soil. After several centuries an upper layer, moderately high in organic matter, was formed in the soils. In this beginning stage of profile development, the lower part retained the color and texture of the parent material. Many centuries later, the lower part changed.

The effect is somewhat different in wet and in well-drained soils. In wet soils the lack of oxygen in the soil causes chemical reduction of iron compounds. The lower part of the soil then becomes olive gray and gleyed. If the soil is naturally well drained, as in the Monona and Salix soils, the lower part of the subsoil develops a more brownish color than the parent material.

In virgin soils the formation of organic matter by vegetation is in equilibrium with the decomposition of organic matter by micro-organisms, and the content of nitrogen is fairly constant. The content of nitrogen is higher in the soils of northern semihumid areas.

The Castana, Colo, Kennebec, Napier, and Zook soils normally have thick, dark surface layers. They are typical of soils formed under prairie. Their parent materials were slowly augmented by new deposits and were changed progressively by slow deposition. These soils contrast with soils that have developed from parent material deposited at a rapid rate.

[3] Italic numbers in parentheses refer to Literature Cited, p. 41.

Soils formed under forest have thinner, darker surface layers than soils formed under prairie vegetation. None of the soils in this county, however, show distinctly the characteristics normal for soils that have formed under forest. An estimated 90 percent of the county was covered by prairie grasses at the time the county was settled, and about 10 percent, by trees. The early settlers destroyed the original prairie grasses by cultivating and grazing the marginal lands. Some of the fields were later abandoned, and trees invaded the areas. As a result there are probably more trees in the county at the present time than when the county was first settled (*5*).

Relief and natural drainage

Many of the differences among soils are related to differences in relief. As a rule the steeper the slope, the greater the amount of runoff and the lower the content of moisture in the soil. According to Aandahl (*1*), the slope features that affect the soil properties and the soil-plant relationship are (1) the general setting in the landscape, (2) gradient, (3) curvature, (4) length, and (5) exposure.

In an area of soils under virgin prairie that Aandahl examined in Ida County, he found that the soils on the steepest slopes contained more nitrogen than those on milder slopes. The soils he examined, though steep, were on east-facing slopes in a cove opening to the north. Therefore, he concluded that protection from the direct rays of the sun and from the drying southwest winds were important factors that caused the soils to have a high content of nitrogen. Differences between soil series, caused in part by differences in relief, can be seen in the Ida and Monona soils and in the Shelby and Steinauer soils in this county. The steeper slopes on which the Ida soils occur are responsible, to some extent, for the differences between these soils and the Monona soils, and the steeper slopes of the Steinauer soils cause them to differ from the Shelby soils.

Drainage is also an important factor that causes differences among the soils. It is partly responsible, for example, for the differences between the soils of the Salix series and the soils of the Luton series. The Luton soils, formed from alluvial clay, generally have a high water table, but in the Salix soils, which were formed from silty alluvium, the water table is low. The Luton soils are wet; consequently, a thick dark surface layer has developed, and the soils have olive-gray to gray lower layers. The Salix soils, which are seldom wet, are yellowish brown.

Climate

The climate is fairly uniform throughout Monona County, but minor local variations, caused particularly by slope and exposure to prevailing winds, have influenced the formation of the soils. The prevailing winds in summer are from the southwest. The steeper eastern slopes of the soils in association 4 are somewhat protected from these winds. They commonly have a more abundant cover of vegetation than the soils on west-facing slopes. The Castana and Monona soils on the east-facing slopes have steeper relief than those on west-facing slopes. Ordinarily, the greater the amount of effective moisture, the greater the amount of minerals leached from the soil. Therefore, the steeper slopes and those exposed more directly to the winds tend to be less leached.

Time

Time is a factor in soil development. If the parent material has been in place for only a short time, the climate and vegetation have not had an opportunity to act on the soils, and the soils are said to be young. The Albaton, Haynie, McPaul, Modale, Onawa, and Sarpy soils are young. They are Alluvial soils forming from recently deposited sediments. The sediments were deposited within the last few centuries, some even within the last few years. The profiles of these soils have not had time to develop.

The Blencoe, Colo, Cooper, Kennebec, Luton, Napier, Salix, and Zook soils, on the other hand, are forming from sediments deposited during an earlier period, probably after the Mankato subage. Their profiles show more development than the profiles of the soils derived from recent alluvium. The maximum age of the Ida and Monona soils is about 11,000 years. The till from which the Shelby and Steinauer soils have formed is much older. It was deposited during the Kansan glacial age and perhaps partly during the Nebraskan age.

The longer the parent material is in place, the more nearly the soil reaches equilibrium with its environment. Soils that have been in place a long time and that have reached equilibrium with their environment are called mature, or old. Their profiles are well developed.

Man alters the soils

Man has become important to the future direction and rate of development of the soils. His use of the soil has been both constructive and destructive. Where he has cultivated slopes without using conservation practices, runoff has increased, and the soils have become eroded. Most of the moderately dark surface layer of the Ida soils, probably 6 to 10 inches thick before cultivation, has been lost through erosion. The same is true of the eroded phases of the Monona soils. Many deep gullies undoubtedly have formed and extended through increased runoff caused by cultivation without conservation. Some gully extension in the uplands may have been accelerated by the straightening of stream channels.

Large areas of the bottom lands have been improved and made suitable for cultivation by establishing drainage ditches. Man has learned to counteract deficiencies in plant nutrients so that the supply can be conserved and the soils made more productive than in the virgin state.

Man's practices will be reflected in the future direction and rates of soil genesis, but these may not be evident for centuries. In many places man's activity has drastically changed the complex of living organisms that affects soil genesis.

Classification of Soils

The higher categories of soil classification, used mainly by scientists, are discussed in this section. With reference to these higher categories, it will be of some help

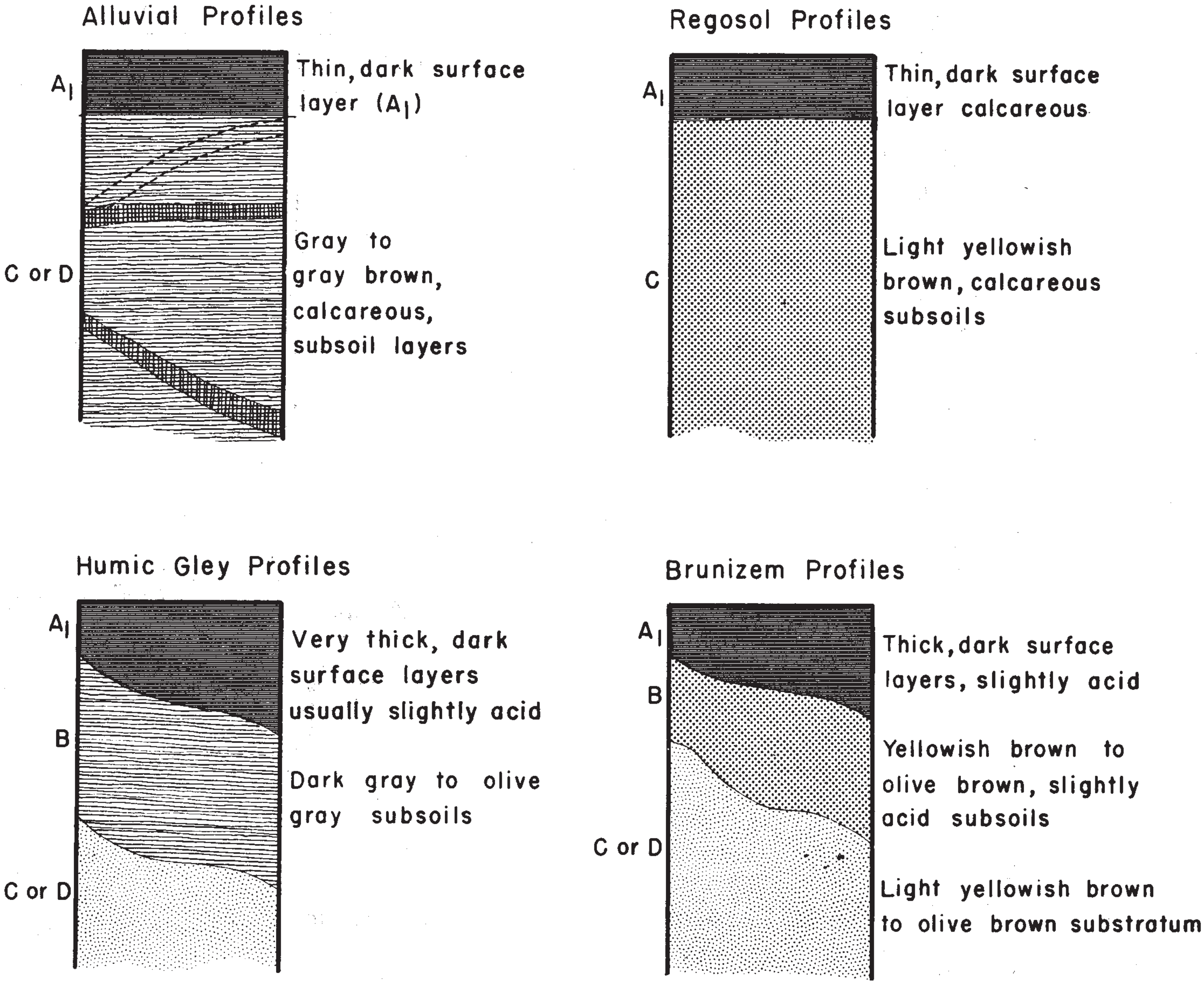


***Figure 7.*—Diagram of major soil profiles in Monona County.**

to the reader to know the major kinds of profiles that occur in this county. Figure 7 shows the four major profiles in the county. They are discussed in the following pages.

Major soil profiles in Monona County

Major Profile I: (Regosol) — The soils that have this kind of profile have a moderately dark surface layer that in most places is less than 6 inches thick. This overlies a light-yellow C horizon. The texture of these soils is clay loam or silt, and the profiles are calcareous throughout. The soils of the Hamburg, Ida, and Steinauer series, which occur in associations 4 and 5, have this kind of profile. They belong to the Regosol great soil group.

Major Profile II: (Alluvial) — In this group the soils have a moderately dark to light-colored surface layer that is less than 6 inches thick. This overlies a grayish to brownish-gray subsoil. The texture of these soils ranges from sand to clay, and in most places there is some stratification. The profile is generally calcareous throughout. The soils of the Albaton, Haynie, McPaul, Modale, Onawa, and Sarpy series occur in association 1. They are classed as Alluvial soils.

446458—58——3

Major Profile III: (Brunizem) In this kind of profile, the surface layer is dark colored and is 12 to 20 inches thick. It overlies a yellowish-brown to olive-brown lower layer. The texture of the various layers is silt loam to silty clay loam in most places. The surface layer and the upper part of the subsoil are generally slightly acid. The soils of the Blencoe, Castana, Cooper, Kennebec, Monona, Napier, Salix, and Shelby series have this kind of profile. They occur in associations 2, 3, 4, and 5. They are Brunizems.

Major Profile IV: (Solonetz) Soils that have this kind of profile have a dark-colored surface soil and upper layers, 15 to more than 20 inches thick, that overlie dark-gray to light olive-gray lower layers. The texture of the profile ranges from silty loam to clay. In most places the upper layers range from slightly acid to neutral in reaction. In Monona County the soils that have this kind of profile belong to the Colo, Luton, Napa, and Zook series. They are Humic Gley (Wiesenboden) soils, but the Napa resembles a Solonetz soil.

Great soil groups and families

The series, types, and phases have been explained in the section, How a Soil Survey Is Made. In the following pages are explained the higher categories of classification—the great soil groups and families. Table 7 shows the great soil groups, families, and series of Monona County.

A great soil group is a group of soils that have a number of common internal characteristics. It consists of one or more soil families. From this broad grouping of soils, comparisons of the soils of this county can be made with soils of other areas of the State or with soils of other parts of the United States or other continents. This grouping is too broad, however, to be practical in planning the use and management of the soils. Therefore, this classification needs to be broken down into smaller subdivisions—the soil families, series, and phases.

The soil family consists of similar soil series that belong to the same great soil group, or it may consist of only one series. The purpose of this category is to make the similarities and differences among the soils apparent at a level between that of the great soil group and that of the soil series.

ALLUVIAL SOILS

The soils of this great soil group are developing from transported and relatively recently deposited material (alluvium) characterized by a weak modification, or none, of the original material by soil-forming processes. They are the youngest of the soils in the county.

The Alluvial great soil group is divided into three families—the Sarpy, Haynie, and Albaton. Only one series, the Sarpy, is in the Sarpy family. The Haynie family is separated from the Albaton mainly because of differences in the color and texture of the lower layers of the soils. The Onawa series is divided between the Haynie and Albaton families. Onawa silty clay loam, 0 to 1 percent slopes, is in the Haynie family; Onawa silty clay, 0 to 1 percent slopes, is in the Albaton.

TABLE 7.—*Great soil groups, families, and series*

Great soil group or major profile	Family	Series
Alluvial	Sarpy	Sarpy.
	Haynie	Haynie. McPaul. Modale. Onawa.
	Albaton	Albaton. Onawa.
Regosol	Ida	Ida. Hamburg. Steinauer.
Brunizem	Monona	Monona. Salix. Shelby.
	Napier	Napier. Castana. Kennebec.[1]
	Blencoe	Blencoe. Cooper.
Humic Gley (Wiesenboden)	Luton	Luton. Zook.[1]
	Colo	Colo.[1]
	Napa [2]	Napa.[2]

[1] Colo silty clay loam, calcareous variant, 0 to 1 percent slopes; Kennebec silt loam, calcareous variant, 0 to 1 percent slopes; and Zook silty clay, calcareous variant, 0 to 1 percent slopes, were not included with their respective series in this classification.

[2] This soil could be classified as a Solonetz.

REGOSOLS

Regosols consist of deep, soft mineral deposits in which few if any clearly expressed soil characteristics have developed. They are largely confined to recent sand dunes and to loess and glacial drift of steeply sloping land.

In Monona County only one family is in the Regosol great soil group. This is the Ida family, which consists of the Ida, Hamburg, and Steinauer series. The Ida and Hamburg soils differ somewhat from the Steinauer soils.

BRUNIZEMS

Brunizems, or Prairie soils, have a very dark brown or grayish-brown surface soil. The profile becomes lighter colored with increasing depth, until the lighter colored parent material is reached at depths of 2 to 5 feet. The Brunizems have developed under tall grasses in a temperate, rather humid climate. The term has a restricted meaning in soil science and is not applied to all the dark-colored soils of the treeless plains. It is applied only to those soils in which carbonates have not been concentrated in any part of the profile by the soil-forming processes (*8, 9*).

In Monona County the Brunizem great soil group is comprised of three families—the Monona, the Napier, and the Blencoe.

The Monona family is made up of the Monona, Salix, and Shelby series. The soils of the Monona and Salix series are similar in texture and consistence. The soils of the Shelby series are somewhat finer textured and are not so permeable as the soils of the Monona and Salix series.

The Napier family is made up of the Napier, Castana, and Kennebec series. Though classified as Brunizems, the soils of this family grade toward the Alluvial soils. Of this family, the Kennebec soils are somewhat grayer in color than the other soils, which would indicate that they are occasionally saturated by high water.

The Blencoe family is comprised of the Blencoe and Cooper series. The soils of these two series grade toward the Humic Gley (Wiesenboden) soils. They have somewhat grayer colors in their lower layers than the soils of either the Monona or Napier families.

HUMIC GLEY (WIESENBODEN)

Humic Gley soils are poorly drained to very poorly drained hydromorphic soils. They have dark-colored organic-mineral horizons of moderate thickness underlain by mineral gley horizons. They occur naturally under wet prairie, swamp-forest, or herbaceous marsh vegetation, mostly in humid and subhumid climates that vary greatly in thermal efficiency. A large proportion of the Humic Gley soils range from medium acid to mildly alkaline in reaction. Few are strongly acid (*10*).

Three families—the Luton, Colo, and Napa—are in the Humic Gley (Wiesenboden) great soil group. The Luton family consists of the Luton and Zook series. The Colo family has in it only the Colo series. The Colo family has been separated from the Luton family on the basis of the texture of the soils and because the Luton soils have grayer colors in the lower layers.

The Napa series, a minor one in the county, could be classed as solonetzic, but its lower subsoil is like the soils of the Luton family, so it has been listed as belonging to the Humic Gley, or Wiesenboden, great soil group.

The calcareous variants of the Zook, Colo, and Kennebec series have not been included with the respective series in table 7.

Laboratory Determinations

Mechanical and chemical analyses and pH values are given in table 8 for five soils in Monona County.

TABLE 8.—*Physical and chemical properties of six soils*

Soil and profile number	pH	Exchangeable cations per 100 gm.					Total	Organic matter	Sand	Silt	Clay
		Ca	Mg	K	Na	H+	N				
Blencoe silty clay (P–147):[1]											
Depth in inches:		*Meq.*	*Meq.*	*Meq.*	*Meq.*	*Meq.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0 to 6	6.2	25.5	6.8	1.0	0.02	2.8	0.22	2.8	10.5	42.4	42.4
6 to 12	6.2	24.4	5.6	.6	.04	2.7	.04				
12 to 18	6.4	23.2	6.4	.6	.05	2.1	.07	----	----	----	----
18 to 24	6.5	19.7	4.6	.5	.05	1.7	.97	1.0	25.5	34.0	18.4
24 to 30	6.8	----	----	----	----	----	.13	----	----	----	----
30 to 36	7.2	14.7	3.5	.3	.10	.2	.06	----	----	----	----
36 to 42	7.4	----	----	----	----	----	.05	.4	32.9	48.5	17.4
48 to 54	8.2	----	----	----	----	----	.04	----	----	----	----
Kennebec silt loam (P–150):[1] Site 200 yards east of Maple River on highway west of Castana near top of S½ sec. 24, T. 84 N., R. 44 W.											
Depth in inches:											
0 to 8	7.2	21.8	7.1	.5	.08	.8	.19	----	11.1	63.9	25.0
8 to 16	6.6	22.6	7.2	.4	.09	2.1	.18	----	----	----	----
16 to 22	6.1	21.6	6.6	.4	.10	3.5	.16	----	----	----	----
22 to 30	6.1	20.3	5.6	.4	.11	3.4	.12	----	4.6	65.5	29.9
30 to 38	6.2	18.0	4.8	.4	.12	2.8	.09	----	----	----	----
38 to 46	6.4	16.5	5.0	.4	.12	1.5	.06	----	----	----	----
46 to 54	6.6	16.4	5.4	.5	.12	2.0	.05	----	----	----	----
Luton clay (P–141):[2] Site 30 yards north of SW corner, NW¼ sec. 12, T. 83 N., R. 45 W.											
Depth in inches:											
0 to 4	6.2	28.0	9.8	1.7	.02	2.9	.27	----	----	----	46.8
4 to 8	6.2	29.6	9.8	1.1	.04	2.7	.27	----	----	----	----
8 to 12	6.3	30.1	9.8	.8	.11	2.1	.23	----	----	----	48.2
12 to 16	6.8	30.3	10.0	.7	.20	1.1	.15	----	----	----	----
16 to 20	7.0	----	----	----	----	----	.11	----	----	----	56.0
20 to 25	7.2	32.2	11.0	.8	.36	.14	.09	----	----	----	----
25 to 30	7.4	----	----	----	----	----	.07	----	----	----	56.7
30 to 36	7.5	32.1	10.9	.9	.46	----	.07	----	----	----	----
36 to 44	7.5	----	----	----	----	----	.06	----	----	----	55.9
44 to 52	7.6	30.1	9.6	1.0	.44	----	.05	----	----	----	----

See footnotes at end of table.

TABLE 8.—*Physical and chemical properties of six soils*—Continued

Soil and profile number	pH	Exchangeable cations per 100 gm.					Total	Organic matter	Sand	Silt	Clay
		Ca	Mg	K	Na	H+	N				
Luton silty clay (P–149):											
Depth in inches:		*Meq.*	*Meq.*	*Meq.*	*Meq.*	*Meq.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
0 to 7	6.7	26.2	6.9	2.4	.00	1.9	0.25	------	5.1	52.3	41.7
7 to 15	6.9	22.4	6.4	2.9	.02	1.5	.16	------	------	------	------
15 to 21	6.6	21.2	7.5	3.4	.03	1.6	.12	------	8.5	47.0	44.5
21 to 29	6.8	------	------	------	------	------	.09	------	------	------	------
29 to 37	6.8	21.2	7.6	2.9	.10	1.0	.06	------	------	------	------
37 to 43	6.8	------	------	------	------	------	.05	------	------	------	------
43 to 49	6.9	11.1	3.5	1.6	.01	.8	.03	------	36.3	47.8	15.9
Monona silt loam (P–145):[3] Site NE¼SE¼NE¼, sec. 23, T. 82 N., R. 42 W.											
Depth in inches:											
0 to 3	------	21.3	9.0	1.05	------	1.2	------	------	------	------	27.8
6 to 9	------	14.0	5.9	.81	------	2.8	------	------	------	------	30.4
12 to 15	------	12.9	5.8	.36	------	2.9	------	------	------	------	26.8
18 to 21	------	11.8	5.7	.23	------	2.3	------	------	------	------	22.6
30 to 34	------	11.1	5.1	.18	------	1.0	------	------	------	------	22.2
54 to 60	------	12.7	5.4	------	------	------	------	------	------	------	18.8
88 to 110	------	------	------	------	------	------	------	------	------	------	16.7
Salix silt loam (P–153): Site 50 yards south of NE corner, SE¼ sec. 24, T. 85 N., R. 45 W.											
Depth in inches:											
0 to 7	7.5	21.8	5.9	1.3	.08	------	.25	2.87	16.6	61.0	22.4
7 to 14	7.1	19.0	3.2	1.1	.06	1.0	.19	------	------	------	------
14 to 19	7.1	14.3	4.1	.6	.06	.7	.12	------	------	------	------
19 to 25	7.2	12.1	4.0	.4	.07	.4	.08	.83	21.3	61.6	17.1
25 to 32	7.2	11.9	4.2	.4	.06	.3	.07	------	------	------	------
32 to 38	7.5	------	------	------	------	------	.06	------	------	------	------
40 to 44	8.1	------	------	.5	.10	------	.06	.36	6.3	76.0	17.7
44 to 50	8.2	------	------	------	------	------	.03	------	------	------	------
50 to 60	8.1	------	------	.4	.10	------	.03	------	------	------	------

[1] Data on organic matter, sand, silt, and clay (less than 0.002 mm. diameter) by the United States Department of Agriculture; other data by Department of Agronomy, Iowa Agricultural Experiment Station.

[2] Data by Department of Agronomy, Iowa Agricultural Experiment Station.

[3] Data by C. E. Hutton *(3)*.

Engineering Applications[4]

This soil survey report for Monona County, Iowa, contains information that can be used by engineers to—

1. Make soil and land use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.
2. Assist in designing drainage and irrigation structures and planning dams and other structures for water and soil conservation.
3. Make reconnaissance surveys of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed soil surveys for the intended locations.
4. Locate sand and gravel for use in structures.
5. Correlate pavement performance with types of soil and thus develop information that will be useful in designing and maintaining the pavements.
6. Determine the suitability of soil units for cross-country movements of vehicles and construction equipment.
7. Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making soil maps and reports that can be readily used by engineers.

[4] This section was prepared by the Division of Physical Research, Bureau of Public Roads. Test data in table 9 were obtained in the Soils Laboratory, Bureau of Public Roads.

The mapping and the descriptive report are somewhat generalized, however, and should be used only in planning more detailed field surveys to determine the in-place condition of the soil at the site of the proposed engineering construction.

Soil Science Terminology

Some of the terms used by the agricultural soil scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, sand, aggregate, and granular—may have special meanings in soil science. These terms are defined as follows:

Aggregate, soil. A cluster of primary soil particles held together by internal forces to form a clod or fragment.

Clay. A soil separate or size group of mineral particles less than 0.002 mm. in diameter. Clay as a textural class is soil material that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Granular structure. Individual grains grouped into spherical aggregates that have indistinct sides. Highly porous granules are commonly called crumbs.

Sand. A soil separate that ranges in diameter from 2.0 mm. to 0.05 mm. As a textural class, sand is any soil material that contains 85 percent or more sand, and the percentage of silt plus 1½ times the percentage of clay does not exceed 15.

Silt. A soil separate that ranges in diameter from 0.05 mm. to 0.002 mm. As a textural class silt is any soil material that contains 80 percent or more silt and less than 12 percent clay.

Soil. The natural medium for the growth of land plants. It is a natural body of organic and mineral materials in which plants grow.

Topsoil. Presumably fertile soil material used to topdress roadbanks, gardens, and lawns.

Soil Test Data and Engineering Soil Classifications

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 in-place condition of the soil. After testing soil materials and observing the behavior of soils when used in engineering structures and foundations, the engineer can develop design recommendations for the soil units delineated on the map.

Soil test data

Soil samples from the principal soil type of each of 10 extensive soil series were tested in accordance with standard procedures (*2*) to help evaluate the soils for engineering purposes. The test data are given in table 9. These test data are considered to be normal for the specific sampling depths in the respective soils. However, considerable variation in texture and plasticity should be anticipated in each of the soils developed from alluvium.

The engineering soil classifications in table 9 are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by using combined sieve and hydrometer methods. The percentages of clay obtained by the hydrometer method should not be used by soil scientists in naming soil texture classes.

The liquid limit and plastic limit tests measure the effect of water on the consistence 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 a 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 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.

Table 9 also gives compaction (moisture-density) data for the tested soils. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material will increase until the "optimum moisture content" is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed "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 classification systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (*2*). 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 soil material is indicated by a group index number. The group index numbers range from 0 for the best materials to 20 for the poorest. The group index number is shown in parentheses, following the soil group symbol, in the next to last column in table 9. The principal characteristics according to which soils are classified in this system are shown in table 10.

Some engineers prefer to use the Unified soil classification system (*12*). In this system, soil materials are identified as coarse grained (8 classes), fine grained (6 classes), or highly organic. An approximate classification can be made in the field. The principal characteristics of the 15 classes of soil are given in table 11. The classification of the tested soils according to the Unified system is given in the last column of table 9.

Soil Engineering Data and Recommendations

Some of the engineering information can be obtained from the soils map. It will often be necessary, however, to refer to other parts of the report, particularly to these sections: General Nature of the Area; Descriptions of Soils; and Productivity, Management, and Capability.

The soil engineering data in table 12 are based on the soil test data in table 9, on information given in the rest of the report, and on experience with the same kinds of soils in other counties.

The Shelby and Steinauer soils are located in some areas where roads are being constructed to traverse the lower slopes of steep-walled valleys. A perched water table may be encountered in a roadcut where a layer of sandy or gravelly material overlies a layer of clayey material, or the water-bearing layer may occur only a slight depth below the proposed pavement. In places the sand or gravel deposits are extensive and have been exploited for use in pavements or other engineering structures. Pavements in cut sections may be subject to differential frost heave where the subgrade contains pockets of very permeable material interspersed with clayey material.

Frost heaving is normally not a problem in the soils of this county derived from loess because of the great depth to the water table. However, frost heave of pavements may occur in cut sections where only a few feet of loess overlies the clayey glacial till. A peculiar characteristic of the calcareous loess (Hamburg and Ida soils) is that vertical backslopes of roadcuts are relatively unsusceptible to slumping. The soils derived from loess are very susceptible to erosion when the runoff is concentrated; hence, sod, paving, or check dams are needed in gutters and ditches to prevent excessive erosion.

TABLE 9.—*Engineering test data* [1] *for soil samples*

Soil name and location	Parent material	Bureau of Public Roads report number	Depth	Moisture-density: Maximum dry density	Moisture-density: Optimum moisture content
			Inches	*Lb. per cu. ft.*	*Percent*
Albaton clay:					
SW corner of sec. 3, T. 83 N., R. 46 W	Alluvium	88182	12–20	88	27
Haynie silt loam:					
SE corner of SW¼NW¼ sec. 34, T. 85 N., R. 46 W	Alluvium	88183	14–20	107	17
Ida silt loam:					
Middle of SE¼ sec. 5, T. 84 N., R. 44 W	Loess	88184	12–20	107	18
25 yd. S. and 15 yd. E. of SW corner of NW¼ sec. 24, T. 82 N., R. 42 W.	Loess	88185	14–20	107	18
Luton clay:					
SW corner of NW¼ sec. 12, T. 83 N., R. 45 W	Alluvium	88186	2–10	90	29
		88187	18–24	92	28
Monona silt loam:					
NE corner of SE¼NE¼ sec. 23, T. 82 N., R. 42 W	Loess	88188	2–8	97	23
		88189	12–18	102	21
		88190	30–36	107	19
Napa clay:					
NE corner of W½SW¼ sec. 3, T. 85 N., R. 45 W	Alluvium	88191	10–16	97	24
Napier silt loam:					
NW corner of SW¼SW¼ sec. 29, T. 84 N., R 42 W	Alluvium	88192	12–18	98	23
Salix silt loam:					
70 yd. S. of NE corner, SE¼ sec. 24, T. 85 N., R. 46 W	Alluvium	88193	0–10	100	21
		88194	40–45	106	20
Sarpy loamy fine sand:					
270 yd. E. of middle sec. 11, T. 83 N., R. 46 W	Alluvium	88195	14–28	113	12
Steinauer loam:					
Middle N. side of sec. 26, T. 85 N., R. 44 W	Glacial till	88196	24–30	113	16

[1] Tests performed by Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials (A. A. S. H. O.) (*2*).

[2] Mechanical analyses made according to the A. A. S. H. O. Designation: T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the A. A. S. H. O. 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 mm. in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser

TABLE 10.—*Classification of soils by American*

General classification	Granular materials (35 percent				
Group classification	A–1		A–3	A–2	
	A–1–a	A–1–b		A–2–4	A–2–5
Sieve analysis:					
Percent passing—					
No. 10	50 maximum.				
No. 40	30 maximum.	50 maximum.	51 minimum.		
No. 200	15 maximum.	25 maximum.	10 maximum.	35 maximum.	35 maximum.
Characteristics of fraction passing No. 40 sieve:					
Liquid limit			NP [2]	40 maximum.	41 minimum.
Plasticity index	6 maximum.	6 maximum.	NP	10 maximum.	10 maximum.
Group index	0	0	0	0	0
Usual types of significant constituent materials.	Stone fragments, gravel, and sand.	Stone fragments, gravel, and sand.	Fine sand.	Silty gravel and sand.	Silty gravel and sand.
General rating as subgrade	Excellent to good				

[1] 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, A. A. S. H. O. Designation: M 145–49.

taken from 10 soil profiles, Monona County, Iowa

Mechanical analysis [2]										Liquid limit	Plasticity index	Classification	
Percentage passing sieve [3]						Percentage smaller than—[3]						A. A. S. H. O.[4]	Unified [5]
3/8 in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
------	------	------	------	100	99	98	96	80	63	78	46	A–7–5(20)	CH
------	------	------	------	100	89	85	65	19	14	30	8	A–4(8)	ML–CL
------	------	------	------	100	99	93	68	22	18	34	10	A–4(8)	ML–CL
------	------	------	------	100	99	96	70	27	22	37	12	A–6(9)	ML–CL
------	------	------	------	100	99	98	89	61	50	66	37	A–7–6(20)	CH or OH
------	------	100	99	99	99	99	96	79	66	84	54	A–7–5(20)	CH
------	------	------	------	100	99	97	69	35	28	48	20	A–7–6(14)	ML–CL
------	------	------	------	100	99	98	84	35	29	46	20	A–7–6(13)	ML–CL
------	------	------	------	100	99	96	77	30	23	38	14	A–6(10)	ML–CL
------	------	100	99	98	88	86	77	53	46	81	58	A–7–6(20)	CH
------	------	------	------	100	99	96	68	29	24	44	17	A–7–6(12)	ML–CL
------	------	------	------	100	97	92	64	30	25	40	14	A–6(10)	ML–CL or OL
------	------	------	------	100	99	96	70	30	24	36	12	A–6(9)	ML–CL
------	------	------	100	91	35	30	19	8	6	NP	NP	A–2–4(0)	SM
100	99	98	92	85	72	69	59	39	32	41	24	A–7–6(13)	CL

than 2 mm. in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming texture classes for soils.

[3] Based on total material. Laboratory test data corrected for amount discarded in field sampling.

[4] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1, ed. 7) (*2*). The Classification of Soils and Soil-Aggregate Mixtures for Highway Purposes, A. A. S. H. O. Designation: M 145–49.

[5] Based on the Unified Soil Classification System, Tech. Memo. No. 3–357, vol. 1, Waterways Experiment Station, Corps of Engineers, March 1953 (*12*).

Association of State Highway Officials [1]

or less passing No. 200 sieve)		Silt-clay materials (More than 35 percent passing No. 200 sieve)				
A–2—Continued		A–4	A–5	A–6	A–7	
A–2–6	A–2–7				A–7–5	A–7–6
35 maximum.	35 maximum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.
40 maximum. 11 minimum.	41 minimum. 11 minimum.	40 maximum. 10 maximum.	41 minimum. 10 maximum.	40 maximum. 11 minimum.	41 minimum. 11 minimum.[3]	41 minimum. 11 minimum.[3]
4 maximum.	4 maximum.	8 maximum.	12 maximum.	16 maximum.	20 maximum.	20 maximum.
Clayey gravel and sand.	Clayey gravel and sand.	Nonplastic to moderately plastic silty soils.	Highly elastic silts.	Medium plastic clays.	Highly plastic clays.	Highly plastic clays.
		Fair to poor				

[2] NP—Nonplastic.

[3] Plasticity index of A–7–5 subgroup is equal to, or less than, LL minus 30. Plasticity index of A–7–6 subgroup is greater than LL minus 30.

TABLE 11.—*Characteristics of soil groups*

Major divisions	Group symbol	Soil description	Value as foundation material [2]	Value as base course directly under bituminous pavement
Coarse-grained soils (*less than 50 percent passing No. 200 sieve*):				
Gravels and gravelly soils (*more than half of coarse fraction retained on No. 4 sieve*).	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	Excellent	Good
	GP	Poorly graded gravels and gravel-sand mixtures; little or no fines.	Good to excellent	Poor to fair
	GM	Silty gravels and gravel-sand-silt mixtures.	Good	Poor to good
	GC	Clayey gravels and gravel-sand-clay mixtures.	Good	Poor
Sands and sandy soils (*more than half of coarse fraction passing No. 4 sieve*).	SW	Well-graded sands and gravelly sands; little or no fines.	Good	Poor
	SP	Poorly graded sands and gravelly sands; little or no fines.	Fair to good	Poor to not suitable
	SM	Silty sands and sand-silt mixtures	Fair to good	Poor to not suitable
	SC	Clayey sands and sand-clay mixtures	Fair to good	Not suitable
Fine-grained soils (*more than 50 percent passing No. 200 sieve*):				
Silts and clays (*liquid limit of 50 or less*).	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, and clayey silts of slight plasticity.	Fair to poor	Not suitable
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays.	Fair to poor	Not suitable
	OL	Organic silts and organic clays having low plasticity.	Poor	Not suitable
Silts and clays (*liquid limit greater than 50*).	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils and elastic silts.	Poor	Not suitable
	CH	Inorganic clays having high plasticity and fat clays.	Poor to very poor	Not suitable
	OH	Organic clays having medium to high plasticity and organic silts.	Poor to very poor	Not suitable
Highly organic soils	Pt	Peat and other highly organic soils	Not suitable	Not suitable

[1] Based on information in The Unified Soil Classification System, Technical Memorandum No. 3-357, vol. 1, 2, and 3, Waterways Experiment Station, Corps of Engineers, 1953 (*12*). Ratings and ranges in test values are for guidance only. Design should be based on field survey and test of samples from construction site.

The lower parts of the bottom lands may be flooded each year, and other areas represented by the Albaton, Haynie, Modale, and Onawa soils are flooded at greater intervals. The roadway in these lowlands should be constructed on a continuous embankment that extends above the level of these frequent floods. The fine sand and silt layers of alluvial soils are susceptible to differential frost heave; hence, proper roadway drainage should be provided and foundation materials that are not susceptible to frost action should be used when pavements are to be constructed at an elevation only a few feet above the water table in these soils.

in Unified soil classification system [1]

Value for embankments	Compaction: Characteristics and recommended equipment	Approximate range in A.A.S.H.O. maximum dry density [3]	Field (in-place) CBR	Subgrade modulus k	Drainage characteristics	Comparable groups in A.A.S.H.O. classification
		Lb./cu. ft.		*Lb./sq.in./in.*		
Very stable; use in pervious shells of dikes and dams.	Good; use crawler-type tractor, pneumatic-tire roller, or steel-wheel roller.	125–135	60–80	300+	Excellent	A–1.
Reasonably stable; use in pervious shells of dikes and dams.	Same	115–125	25–60	300+	Excellent	A–1.
Reasonably stable; not particularly suited to shells but may be used for impervious cores or blankets.	Good, but needs close control of moisture; use pneumatic-tire or sheepsfoot roller.	120–135	20–80	200–300+	Fair to practically impervious.	A–1 or A–2.
Fairly stable; may be used for impervious core.	Fair, use pneumatic-tire or sheepsfoot roller.	115–130	20–40	200–300	Poor to practically impervious.	A–2.
Very stable; may be used in pervious sections; slope protection required.	Good; use crawler-type tractor or pneumatic-tire roller.	110–130	20–40	200–300	Excellent	A–1.
Reasonably stable; may be used in dike section having flat slopes.	Same	100–120	10–25	200–300	Excellent	A–1 or A–3.
Fairly stable; not particularly suited to shells but may be used for impervious cores or dikes.	Good, but needs close control of moisture; use pneumatic-tire or sheepsfoot roller.	110–125	10–40	200–300	Fair to practically impervious.	A–1, A–2, or A–4.
Fairly stable; use as impervious core for flood-control structures.	Fair; use pneumatic-tire or sheepsfoot roller.	105–125	10–20	200–300	Poor to practically impervious.	A–2, A–4, or A–6.
Poor stability; may be used for embankments if properly controlled.	Good to poor; close control of moisture is essential; use pneumatic-tire or sheepsfoot roller.	95–120	5–15	100–200	Fair to poor	A–4, A–5, or A–6.
Stable; use in impervious cores and blankets.	Fair to good; use pneumatic-tire or sheepsfoot roller.	95–120	5–15	100–200	Practically impervious.	A–4, A–6, or A–7.
Not suitable for embankments	Fair to poor; use sheepsfoot roller.[4]	80–100	4–8	100–200	Poor	A–4, A–5, A–6, or A–7.
Poor stability; use in core of hydraulic fill dam; not desirable in rolled fill construction.	Poor to very poor, use sheepsfoot roller.[4]	70–95	4–8	100–200	Fair to poor	A–5 or A–7.
Fair stability on flat slopes; use in thin cores, blankets, and dike sections of dams.	Fair to poor; use sheepsfoot roller.[4]	75–105	3–5	50–100	Practically impervious.	A–7.
Not suitable for embankments	Poor to very poor; use sheepsfoot roller.[4]	65–100	3–5	50–100	Practically impervious.	A–5 or A–7.
Not used in embankments, dams, or as subgrades for pavements					Fair to poor	None.

[2] Ratings are for subgrade and subbases for flexible pavement.
[3] Determined in accordance with test designation: T 99–49, A.A.S.H.O. (*2*).
[4] Pneumatic-tire rollers may be advisable, particularly when moisture content is higher than optimum.

Some of the clean sand of the Sarpy soils is susceptible to wind erosion; roadway slopes in these soils should be protected from both water and wind erosion.

Ratings are given in table 12 to show the suitability of the soils of Monona County as sources of topsoil for use on embankments, cut slopes, and in ditches, to promote the growth of vegetation. These topsoil materials are generally unsuitable for use on highway shoulders that are to support limited traffic during wet periods.

At many construction sites, major variations in the soil may occur within the depth of the proposed excavation, and several soil units may occur within a short distance.

TABLE 12.—*Engineering characteristics of soils*

GLACIAL TILL

Soil series	Brief description of soil profile and ground condition	Dominant slope	Engineering soil classification: A. A. S. H. O.	Engineering soil classification: Unified	Depth to seasonally high water table	Suitability as source of topsoil [1]
		Percent				
Shelby	Moderately well drained clay loam with some gravel and small stones.	8–35	A–6 or A–7	ML or CL	Deep	Fair to poor.
Steinauer	Moderately well drained calcareous clay loam with some gravel and small stones; occasional pockets of sand or gravelly material.	8–35	A–6 or A–7	CL	Deep	Fair to poor.
LOESS						
Castana	Well-drained slightly calcareous silt loam.	12–18	A–4 or A–6	ML or CL	Deep	Good to depth of 2 feet.
Hamburg	Well-drained calcareous silt	40–60	A–4	ML	Deep	Poor.
Ida	Well-drained calcareous silt loam.	8–20	A–4 or A–6	ML or CL	Deep	Fair to poor.
Monona	Well-drained silt loam	5–30	A–4, A–6, or A–7	ML or CL	Deep	Good to fair.
ALLUVIUM						
Albaton	Very poorly drained clay	0–1	A–7	MH or CH	0–3	Fair to poor.
Blencoe	1½ to 2½ feet of poorly drained silty clay over silt loam; in places the silty clay may extend to a depth of 3½ feet.	0–1	A–7 over A–4 or A–6.	MH or CH over ML or CL.	1–3	Fair to depth of 1–1½ feet.
Colo	Poorly drained to imperfectly drained silty clay loam; in places is silt loam below a depth of 2½ feet; high organic-matter content to a depth of 1 to 1½ feet.	0–1	A–6 or A–7	CL, CH, OL, or OH.	1–3	Good to depth of 1–1½ feet.
Cooper	2½ to 3 feet of imperfectly drained silty clay loam over poorly drained silty clay or clay; in places there is a layer of silt loam or silt at a depth of 2 to 3 feet.	0–1	A–6 or A–7 over A–7.	CL or CH over MH or CH.	2–4	Same.
Haynie	Moderately well drained silt loam, fine sandy loam, or loamy fine sand.	0–2	A–2 or A–4	SM, SC, or CL	0–4	Good to poor.
Kennebec	Moderately well drained silt loam; in places has loamy sand layer at a depth greater than 3½ feet; high organic-matter content to a depth of 1 to 1½ feet.	0–2	A–4 or A–6	SM, ML, CL, or OL.	1–4	Good to depth of 3 feet.
Luton	Very poorly drained clay; in places has a thin layer of silty clay loam or silt loam at a depth of 3 to 4 feet; high organic-matter content to a depth of 1 to 1½ feet.	0–1	A–7	MH, CH, or OH	0–3	Fair to poor to depth of 1–1½ feet.
McPaul	2 to 4 feet of imperfectly drained silt loam over silty clay loam.	0–1	A–4 or A–6 over A–6 or A–7.	ML, or CL over CL or CH.	1–3	Good to depth of 2 feet.
Mixed alluvial land.	Poorly drained stratified materials ranging from sand to clay.	0–1	A–2 to A–7	SM to CH	0–3	Not suitable.
Modale	1½ to 3 feet of imperfectly drained silt loam or sandy loam over poorly drained silty clay. In places sand or silt lenses occur at a depth of 2 to 3 feet.	0–1	A–4 or A–6 over A–7.	ML or CL over MH or CH.	1–3	Good to poor.
Napa	Very poorly drained silty clay	[2] 0	A–7	MH or CH	0–3	Poor to unsuitable.

See footnotes at end of table.

TABLE 12.—*Engineering characteristics of soils*—Continued

ALLUVIUM—continued

Soil series	Brief description of soil profile and ground condition	Dominant slope	Engineering soil classification		Depth to seasonally high water table	Suitability as source of topsoil [1]
			A. A. S. H. O.	Unified		
		Percent			*Feet*	
Napier	Moderately well drained to imperfectly drained silt loam.	1–5	A–4, A–6, or A–7	ML or CL	[3] 2–4	Good to depth of 3 feet.
Onawa	1½ to 3½ feet of imperfectly to poorly drained silty clay loam or silty clay over imperfectly drained silt loam.	0–2	A–6 or A–7 over A–4 or A–6.	CL, MH, or CH over ML or CL.	0–4	Fair.
Salix	Moderately well drained silt loam; in places silty clay loam to a depth of 3½ to 4 feet.	0–2	A–4, A–6, or A–7	ML, CL, or CH	2–5	Good to depth of 2 feet.
Sarpy	½ to 2 feet of well-drained fine sandy loam or loamy fine sand over fine sand.[4]	0–2	A–2 or A–4 over A–2.	SM	[3] 3–5	Poor.
Zook	Very poorly drained silty clay; high organic-matter content to a depth of about 3 feet.	0–1	A–7	MH, CH, or OH	0–3	Fair to depth of 1–1½ feet.

[1] Except where the depth is shown, rating is for the surface of A-horizon material only; the term suitability refers to fitness for use on embankments, on cut slopes, and in ditches to promote the growth of vegetation.

[2] Usually occurs in slight depressions.

[3] Depth to seasonally high water table may be greater than 5 feet in many areas.

[4] Some of sand deposits have been reworked into low dunes by wind; dune material is A–3 (SP).

The soil map and profile descriptions, as well as the engineering data and recommendations given in this section, should be used in planning detailed surveys of soils at construction sites. By using the information in the soil survey report, the soils engineer can concentrate on the most important soil units. Then, a minimum number of soil samples will be obtained for laboratory testing, and an adequate soil investigation can be made at minimum cost.

Literature Cited

(1) AANDAHL, ANDREW R.
1948. THE CHARACTERIZATION OF SLOPE POSITIONS AND THEIR INFLUENCE ON THE TOTAL NITROGEN CONTENT OF A FEW VIRGIN SOILS OF WESTERN IOWA. Soil Sci. Soc. Amer. Proc. 13: 449–454.

(2) AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS.
1955. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING: CLASSIFICATION OF SOILS AND SOIL-AGGREGATE MIXTURES FOR HIGHWAY CONSTRUCTION PURPOSES, DESIGNATION M 145–49.

(3) HUTTON, CURTIS, E.
1950. STUDIES OF THE CHEMICAL AND PHYSICAL CHARACTERISTICS OF A CHRONO-LITHO-SEQUENCE OF LOESS-DERIVED PRAIRIE SOILS OF SOUTHWESTERN IOWA. Soil Sci. Soc. Amer. Proc. 15: 318–324.

(4) KAY, G. F., and GRAHAM, JACK B.
1941. THE ILLINOIAN AND POST-ILLINOIAN PLEISTOCENE GEOLOGY OF IOWA. Iowa Geol. Survey Ann. Rpt., 1940–41, 38: 1–262, illus.

(5) LOOMIS, W. E., and MCCOMB, A. L.
1944. RECENT ADVANCES OF THE FOREST IN IOWA. Iowa Acad. Sci. Proc. 51: 217–224.

(6) RUHE, R. V., and SCHOLTES, W. H.
1956. AGES AND DEVELOPMENT OF SOIL LANDSCAPES IN RELATION TO CLIMATIC AND VEGETATIONAL CHANGES IN IOWA. Soil Sci. Soc. Amer. Proc. 20: 264–273.

(7) SHIMEK, B.
1910. GEOLOGY OF HARRISON AND MONONA COUNTIES. Iowa Geol. Survey Ann. Rpt., 1909, 20: 273–485.

(8) SIMONSON, R. W., RIECKEN, F. F., and SMITH, GUY D.
1952. UNDERSTANDING IOWA SOILS. Dubuque, Iowa.

(9) SMITH, GUY D., ALLAWAY, W. H. and RIECKEN, F. F.
1950. PRAIRIE SOILS OF THE UPPER MISSISSIPPI VALLEY. Advances in Agron. 2: 157–205.

(10) THORP, JAMES, and SMITH, GUY D.
1949. HIGHER CATEGORIES OF SOIL CLASSIFICATION: ORDER, SUBORDER, AND GREAT SOIL GROUPS. Soil Sci. 67: 117–126.

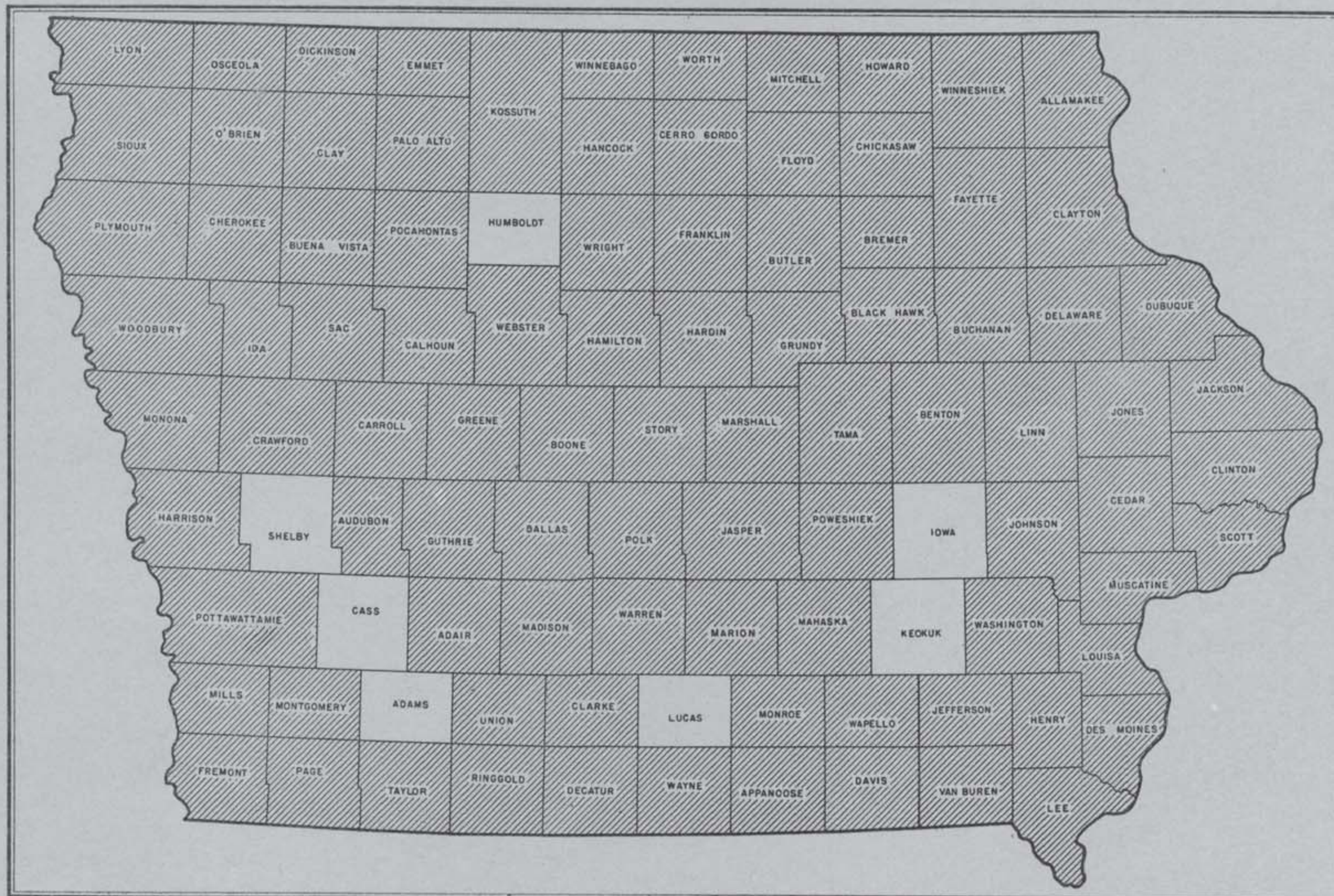
(11) TIMMONS, J. S., CHAIRMAN.
1950. TEAMWORK TOWARD BETTER LAND USE AND SOIL CONSERVATION IN WESTERN IOWA. Iowa Expt. Sta. Spec. Rpt. 4, 27 pp., illus.

(12) WATERWAYS EXPERIMENT STATION.
1953. UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. No. 3–357, vol. 1.

This page intentionally left blank.

Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.



Areas surveyed in Iowa shown by shading.