Series 1956, No. 18

Issued January 1961

SOIL SURVEY

Humboldt County Iowa

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 Humboldt County was made to help you 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 they will do under different kinds of management.

Find your farm on the map

To use this survey, start by finding your farm on the soil map accompanying this report. You can see woods, fields, roads, rivers, and many other landmarks on this map. The index to map sheets will help you locate your farm. It shows what part of the county is on each sheet of the soil map.

Learn about your soils

Each kind of soil mapped in the county is identified on the soil map by a symbol. Suppose you have found on your farm an area marked with the symbol CaC2. You learn the name of the soil this symbol represents by looking at the map legend. The symbol CaC2 identifies Clarion loam, 5 to 9 percent slopes, moderately eroded. To learn how this soil looks in the field and what it can be used for, turn to the section, Soil Series and Mapping Units, and read the description of the Clarion series and the paragraphs about Clarion loam, 5 to 9 percent slopes, moderately eroded.

After you have read the description of the soil, you may want to know more about how it can be managed and how much it can be expected to produce. For this information, turn to table 5 and the section, Soil Management and Productivity.

Make a farm plan

Study the soils on your farm and compare the yields you have been getting with those you could expect under different management. Then decide whether or not you need to change your methods of farming. The choice, of course, must be yours. This report will help you review your farm plan. It does not provide a plan of management for your farm or any other single farm in the county.

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

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Contents

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SOIL SURVEY OF HUMBOLDT COUNTY, IOWA

REPORT BY ELLSWORTH M. RICHLEN,[1] SANFORD M. SMITH, AND DAVID F. SLUSHER, SOIL CONSERVATION SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

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THE SOIL SURVEY of Humboldt County was made by the United States Department of Agriculture in cooperation with the Iowa Agricultural Experiment Station. Fieldwork was begun in 1953 and completed in 1956. Unless otherwise specified, statements in this report refer to conditions in 1956.

This survey was made to determine the important characteristics of the soils; to classify these soils by defined types and other units; to plot on maps the boundaries between different kinds of soils; and to interpret the information obtained in such a way that it will be useful to many people.

General Nature of the Area

Humboldt County is largely agricultural. Most of the soils are suitable for corn and other row crops. Others can be made equally suitable if they are properly drained. Some are too eroded, too steep, or too wet to warrant cultivation.

Location and extent

Humboldt County is in the north-central part of Iowa (see back cover). It measures about 24 miles from east to west and approximately 18 miles from north to south. The county seat, Dakota City, is approximately 90 air miles north-northwest of Des Moines, the State capital. The largest city in the county is Humboldt, which is located just to the west of and adjoining Dakota City. The dividing line is a railroad track.

Physiography

Humboldt County lies within the area covered by the Des Moines lobe of the Late Wisconsin glaciation (*12*).[3] The glacier originated in the Keewatin ice mass, west of Hudson Bay in Canada. It is thought that the Des Moines lobe was laid down in two substages, the Cary and the Mankato (*12, 14*). According to this view, Humboldt County was covered by the youngest, or most recent, glacial substage—the Mankato. Other evidence, however, suggests that the Cary substage was continuous (*13*), and that the Des Moines glacial lobe in Iowa is entirely of the Cary substage.

Along the East Fork Des Moines River in section 3 of Grove Township, there is glacial till that is more highly weathered and probably older than the Mankato till. There is also some evidence of an older till at the base of a gravel pit in section 6 of Avery Township, northwest of the town of Bradgate. Also, along the south road in section 9 of Avery Township, there is glacial till that is presumably older than Mankato or Cary. The extent of these till deposits has not been determined.

Limestone of St. Louis and Kinderhook ages outcrops in Avery, Rutland, Weaver, Corinth, and Beaver Townships, mostly along the East Fork Des Moines River and West Fork Des Moines River (*8*). Limestone underlies 12 to 20 feet of till in Weaver Township and runs in a seam in a northwest-southeast direction. Throughout this area of approximately 6,000 acres there are numerous sinkholes. Limestone sinks also occur in section 4 of Corinth Township.

Numerous small ground moraines rise above the normally undulating topography of the county. The only major moraine in the county is the Rutland moraine, a fork of the broad Altamount-Humboldt complex in Palo Alto County, Iowa. The Rutland moraine, which is the northern phase of the Humboldt system, grades into the Cary ground moraine in the northeastern part of Humboldt County. It is half-moon shaped, and its southernmost point is approximately 2½ miles north of the city of Humboldt.

Much of the upland has only an indistinct drainage pattern and is marked by many landlocked depressions or potholes. The minor upland streams in the easternmost tier of townships in Humboldt County drain into the Boone River in Wright County. The other minor streams drain into both the East and West Forks of the

[1] Employed part time by the Iowa Agricultural Experiment Station.
[2] Employed through funds made available by Office of the Assessor, Humboldt County.
[3] Italic numbers in parentheses refer to Literature Cited, p. 69.

Des Moines River, or into the Des Moines River below the junction of these two.

The East Fork Des Moines River traverses the county in a north-south direction; the West Fork Des Moines River, in a northwest-southeast direction. Three miles south of Dakota City, the two forks join to form the Des Moines River.

An extensive system of manmade drainage ditches has been dug throughout the county to provide surface drainage and outlets for tile drains.

Climate

Iowa has an extreme midcontinental climate. Continental polar air masses, which dominate the Iowa climate throughout the winter, move across Humboldt County from northwest to southeast. Maritime air masses from the south and southwest are dominant in summer.

The average annual precipitation in Humboldt County is 29.74 inches, and the average annual snowfall is 31.8 inches. The lowest temperature recorded is —42° F., and the highest is 111° F. In table 1 are data on temperature and precipitation as recorded at the Dakota City station. Before September 1939, this station was known as Humboldt station.

TABLE 1.—*Temperature and precipitation at Dakota City, Humboldt County, Iowa*

[Elevation, 1,140 feet]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1886)	Wettest year (1909)	Average snowfall
	° F.	° F.	° F.	Inches	Inches	Inches	Inches
December	23.0	65	−26	0.80	0.75	1.36	6.0
January	17.7	66	−42	.87	2.60	2.19	7.2
February	20.8	69	−34	.93	.20	1.89	6.7
Winter	20.5	69	−42	2.60	3.55	5.44	19.9
March	34.2	85	−20	1.40	1.40	2.43	6.5
April	48.1	96	3	2.32	4.60	3.45	1.8
May	59.7	105	20	4.02	1.15	7.14	[3]
Spring	47.3	105	−20	7.74	7.15	13.02	8.3
June	68.9	105	34	4.68	.80	7.10	[3]
July	74.4	110	37	3.50	.35	4.89	[3]
August	71.6	111	34	3.55	3.43	.75	0
Summer	71.6	111	34	11.73	4.58	12.74	[3]
September	63.5	103	21	3.81	.39	4.22	[3]
October	51.7	92	−3	2.10	.90	1.37	.4
November	36.3	81	−23	1.76	2.00	11.48	3.2
Fall	50.5	103	−23	7.67	3.29	17.07	3.6
Year	47.5	111	−42	29.74	18.57	48.27	31.8

[1] Average temperature based on a 64-year record, through 1955; highest and lowest temperatures based on a 61-year record, through 1952.

[2] Average precipitation based on a 72-year record, through 1955; wettest and driest years based on a 72-year record, in the period 1883–1955; snowfall based on a 55-year record, through 1952.

[3] Trace.

The average growing season is May 7 to October 1, a period of 148 days. The average temperature between April 1 and September 30 is about 64° F. The total average precipitation between April 1 and September 30 is approximately 22 inches. A 35-year record shows that the latest frost date was May 31, and the earliest, September 12.

The risk in planting before April 28 or harvesting after October 12 is indicated from records of the station in Pocahontas County, which adjoins Humboldt County on the west, and from records of the West Bend station in Palo Alto County, which is northwest of Humboldt County (*4*). The West Bend station was closed in 1946. Pocahontas station (elevation, 1,270 feet):

Chance of 32° F. after—	*Percent*	Chance of 32° F. before—	*Percent*
April 28	75	Sept. 14	5
May 6	50	Sept. 18	10
May 14	25	Sept. 26	25
May 21	25	Oct. 4	50
May 25	5	Oct. 12	75

West Bend station (elevation, 1,197 feet):

Chance of 32° F. after—	*Percent*	Chance of 32° F. before—	*Percent*
April 29	75	Sept. 11	5
May 7	50	Sept. 15	10
May 15	25	Sept. 23	25
May 22	10	Oct. 1	50
May 25	5	Oct. 9	75

Agriculture

Humboldt County was prairie at the time of settlement, with only a few wooded areas along the streams. Of the 278,400 acres in the county, 96.2 percent is now in farms. Except for a few wet areas and a few steep areas along the major streams, most of the farm acreage is cultivated. Corn is the principal crop.

Farms.—Of the 13,117 people in the county in 1950, 5,932 lived on farms. In 1954 there were 1,410 farms, of which 47.2 percent were operated by owners or part owners and 52.7 percent were operated by tenants. One farm was operated by a manager. The following lists the farms according to size:

Acres	*No. of Farms*
1 to 9	50
10 to 29	27
30 to 49	19
50 to 99	128
100 to 219	752
220 to 499	413
500 or more	21

The average size of farms is 190 acres.

Land use.—The farmland is used chiefly for crops and, less extensively, for pasture. Corn is the principal crop. Oats, soybeans, and hay are also grown extensively. Although grain is the major cash crop, much of it is used on the farm for feed, chiefly for cattle and hogs. Hardly any timber is produced in the county for commercial use, but trees are planted around farmsteads for windbreaks.

The number of acres used for pasture and the number used for the principal crops in 1954 were as follows:

Crops	Acres
Corn, for all purposes	97,037
Oats, threshed or combined	55,065
Soybeans, for all purposes	37,034
Hay, total	24,835
Alfalfa and alfalfa mixtures	12,312
Clover, timothy, and mixtures of clover and grasses	10,935
Other hay	1,588

The numbers of livestock on farms in the county in 1954 were as follows:

Livestock	Number
Cattle and calves	39,868
Milk cows	5,595
Hogs and pigs	114,939
Sheep and lambs	15,895
Horses and mules	421

Soil Survey Methods and Definitions

This section explains how soil maps are made, introduces the reader to some of the terminology used in soil science, and defines terms that have been used to describe the soils. A careful study of the definitions will help the reader to understand the soil descriptions.

Field Study.—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. The soil surveyor bores into the soil with an auger, digs holes with a spade, or examines highway or railroad cuts. The places examined are not spaced in a regular pattern but are located according to the lay of the land. Usually they are not more than a few hundred feet apart. Each area outlined on the soil map has been examined. In complex areas, many borings are made. In most soils, the holes or borings reveal several individual layers, called horizons, which collectively are termed the soil profile (fig. 1). The color, texture, consistence, and porosity of each layer are observed, and the content of stones and gravel is noted. The reaction (or degree of acidity) and the presence of free lime or salts are determined by simple tests. Other factors considered are drainage, both internal (through the soil) and external (over the soil); permeability, which can be measured quantitatively in terms of the rate at which water moves through the soil; moisture-holding capacity; topography; and the interrelation between soil and vegetation.

Soil color.—The color of the topmost layer of soil is usually related to the organic-matter content. Organic matter is the undecomposed or partially decomposed plant stems, roots, or leaves that are found in the soil. The darkest soils are usually those that are highest in organic matter and nitrogen. The colors in the subsoil commonly indicate the drainage of the soil. Gray and olive colors, or streaks and spots of gray and yellow, called mottles, usually indicate poor drainage and aeration. Uniform brown to yellowish-brown colors indicate good drainage and aeration.

Soil texture.—Soil texture is the proportion of the different sizes of particles that make up the soil. The largest soil particles are sand. Sand grains can be seen with the naked eye and feel gritty between the fingers. Silt particles are smaller than sand and feel smooth and floury. Clay particles are smallest of all and can be seen only with electron microscopes. Soils that are high in clay feel dense and sticky. The soil scientist judges the texture by the feel of the soil when it is rubbed between his thumb and forefinger. In many cases, the texture is checked in the laboratory by mechanical analyses.

Some of the terms used to describe texture are silt loam, loam, clay loam, sandy loam, loamy sand, and clay.

Loam is about 20 percent clay, 40 percent silt, and 40 percent sand. Silt loam has much less sand and more silt. It is about 15 percent clay, 20 percent sand, and at least 50 percent silt. Clay loam contains about equal proportions of sand, silt, and clay. Sandy loam, loamy sand, and sand have increasing percentages of sand, in that order. Clay is more than 40 percent clay-sized particles.

Texture has much to do with the quantity of moisture the soil will hold available to plants, the permeability of the soil, and the ease with which the soil can be cultivated. Silt loams and loams are the most desirable soil textures. Clay soils have restricted movement of air and water and are difficult to work. Sandy soils do not have good water-holding capacity and may be droughty.

Soil consistence.—Consistence is the tendency of the soil to crumble or to stick together. It indicates whether it is easy or difficult to keep the soil open and porous under cultivation. Terms used to describe consistence are loose, very friable, friable, slightly firm, firm, very firm, and extremely firm. Friable and slightly firm are the most desirable forms of consistence. The firmer the soil, the more difficult it is to work. Sandy soils are usually loose.

Soil porosity.—Porosity is the term used to indicate the relative volume of the soil occupied by pores or air spaces. We refer to a soil as porous if a large proportion of the total volume consists of coarse pores.

Native vegetation.—Soils that formed under grass vegetation are usually darker in color than soils that formed under trees, when other conditions have been the same. Soils that formed under trees usually are more acid and have thinner surface layers than grassland soils. Some soils have formed under mixed grass-and-timber vegetation and are intermediate in properties between the grassland and forest soils.

Soil permeability.—Permeability is the quality that enables the soil to transmit air and water. It can be measured quantitatively in terms of rate of flow. The relative classes of permeability are very rapid, rapid, moderate, slow, and very slow. Moderate permeability is the most desirable because it permits free movement of air and water, unless the soil has a high water table.

Soil drainage.—Well drained, moderately well drained, imperfectly drained, poorly drained, very poorly drained, and excessively drained are terms used to describe drainage of soils. The terms refer to the natural state of the soil before the drainage has been altered by tile or ditches. For example, a soil that was once too wet for cultivation might now be tile drained and be producing excellent crops, but the drainage class would remain the same. Natural soil drainage is determined by observing soil colors and evaluating soil permeability and by the experience and general observations of the soil scientists.

Excessively drained soils are those from which water is removed very rapidly. They are sandy and very porous. Ordinarily, enough moisture is lost from these soils

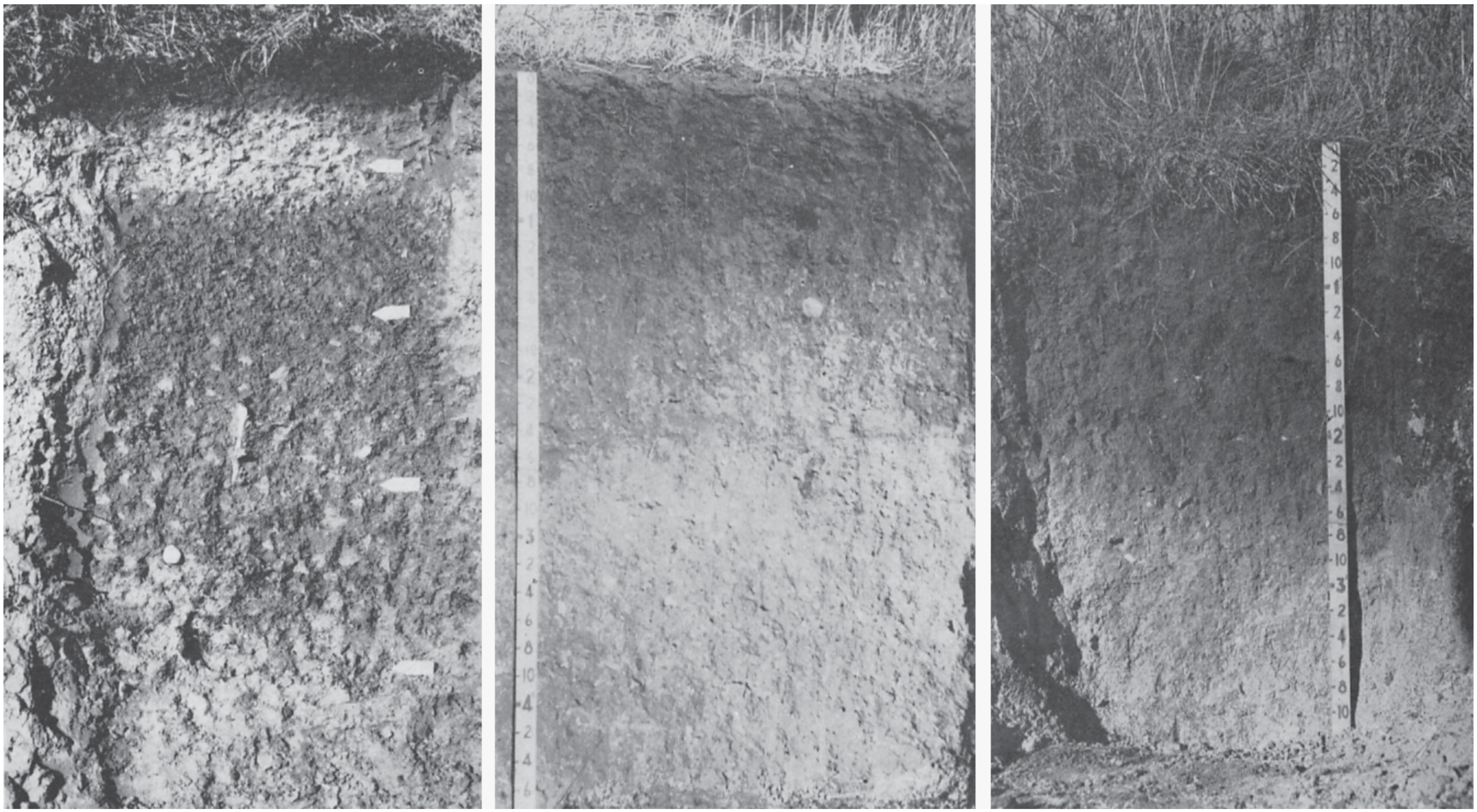

Figure 1.—Profile of Hayden loam (left), Clarion loam (center), and Webster silty clay loam (right). The Webster soil is poorly drained and has a thick, dark-colored surface layer. Clarion loam is well drained and has a surface layer that is thinner than that of Webster silty clay loam and thicker than that of Hayden loam. Hayden loam has a thin surface layer and a higher colored subsurface layer, or A_2 horizon. Hayden loam formed under forest. Clarion loam and Webster silty clay loam formed under prairie.

to make them undesirable for ordinary crops. The Lakeville soils are excessively drained.

Somewhat excessively drained soils are those from which water is removed rapidly. They are sandy, very porous, and droughty even in years of average rainfall. The Ankeny and Farrar soils, for example, are somewhat excessively drained.

Well-drained soils are those from which water is removed readily but not rapidly. They usually retain optimum amounts of moisture for plant growth. Artificial drainage is not needed. The Clarion, Hayden, and Truman soils are examples of well-drained soils.

Moderately well drained soils are those from which water is removed somewhat slowly, so that the profile is wet for a small but significant part of the time. These soils commonly have a slowly permeable layer within or immediately below the subsoil, or they have a relatively high water table, or they receive seepage water, or they have some combination of these conditions. Normally, the growth of crops on these soils is not restricted because of wetness, except in years of excessive rainfall. Moderately well drained soils seldom, if ever, need artificial drainage. The Garmore soils are moderately well drained.

Imperfectly drained soils are those from which water is removed so slowly that the soils are wet for significant periods but not all of the time. Such soils commonly have a slowly permeable layer or a high water table, or they receive seepage water, or they have combinations of these conditions. Most imperfectly drained soils can be cultivated without artificial drainage. In wet years, however, yields may be reduced unless artificial drainage has been provided. The Nicollet and Kato soils are imperfectly drained.

Poorly drained soils are those from which water is removed so slowly that the soils remain wet much of the time. The water table is commonly at or near the surface during a considerable part of the year. Poor drainage is due to a high water table, to a slowly permeable layer within the profile, to seepage, or to some combination of these conditions. The large quantities of water that remain in and on the poorly drained soils prevent satisfactory growth of field crops. Artificial drainage is generally necessary for satisfactory crop production. The Webster and Marshan are examples of poorly drained soils.

Very poorly drained soils are those from which water is removed so slowly that the water table remains at or near the surface the greater part of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded. Unless artificially drained, these soils are too wet for cultivation. The Glencoe and Okoboji soils are examples of very poorly drained soils.

Classification.—Mostly on the basis of the foregoing characteristics, soils that are alike in kind, thickness, and arrangement of their horizons are classified in one soil *series*. A soil series may consist of two or more soil *types* because of differences in texture of the surface soil. A soil type may be subdivided into *phases*—in Humboldt County, primarily because of differences in slope or degree of erosion. For example, a soil that has a slope range of 2 to 9 percent may be mapped in two phases, a gently sloping phase (2 to 5 percent slopes) and a moderately sloping phase (5 to 9 percent slopes); or a soil that has undergone various degrees of erosion may be mapped in two or more phases, a phase that is not more than slightly eroded, a moderately eroded phase, and perhaps a severely eroded phase.

The characteristics that form the basis for subdivision into phases are significant to the use and management of the soil. Yield predictions can be more specific for phases than for the broader categories. Suggestions can be made as to the suitability of the soil for specified crops and specified crop rotations and the need for terracing or other conservation practices.

If very small areas of two or more kinds of soil are so intricately mixed that they cannot be shown separately on a map of the scale used, they are mapped together, and the resulting mapping unit is called a soil complex. For example, the Colo-Terril complex in Humboldt County consists of Colo silty clay loam and Terril loam.

General Soil Areas

Soils occur in characteristic patterns that are related to the underlying material and to topography. Figure 2 shows the five general soil areas of Humboldt County. Each area contains two or more extensive soils and, generally, several less extensive soils. A map showing general soil areas is useful in planning broad agricultural programs.

Area 1.—Level and Nearly Level, Imperfectly Drained and Poorly Drained Upland Soils: Nicollet, Webster

In area 1 are level, poorly drained Webster soils; nearly level, imperfectly drained Nicollet soils; and pothole soils, chiefly Glencoe, Okoboji, and Rolfe. There are also several large areas of Muck and Mucky peat and a few undulating areas of well-drained Clarion soils. All these soils are dark or very dark colored. The Nicollet and Webster soils developed mainly from calcareous glacial till of loam texture. Most of the other soils developed from glacial till or local alluvium. The potholes fill with water after heavy rains (fig. 3).

Area 2.—Mostly Level to Undulating, Well Drained to Poorly Drained Upland Soils: Clarion, Webster

Poorly drained Webster soils occupy the level parts of area 2. Well-drained Clarion soils occupy the slopes. Included in area 2, along the major streams, are some rolling and hilly Storden, Lester, and Hayden soils. Nearly all the soils are dark colored. There are potholes in area 2 that fill with water after heavy rains.

Area 3.—Nearly Level and Undulating Soils That Contain Some Sinkholes: Clarion, Garmore

In this area limestone bedrock is at depths of 10 to 20 feet, which is nearer the surface than in the rest of the county. Rock outcrops in a few places along drainageways. The moderately well drained Garmore soils in area 3 are nearly level. The Clarion soils are more sloping. The soils in this area generally have better natural drainage than those in areas 1 and 2, and they are less likely to need tile. In many places sinkholes or wells drilled in the bedrock are used as outlets for tile drains.

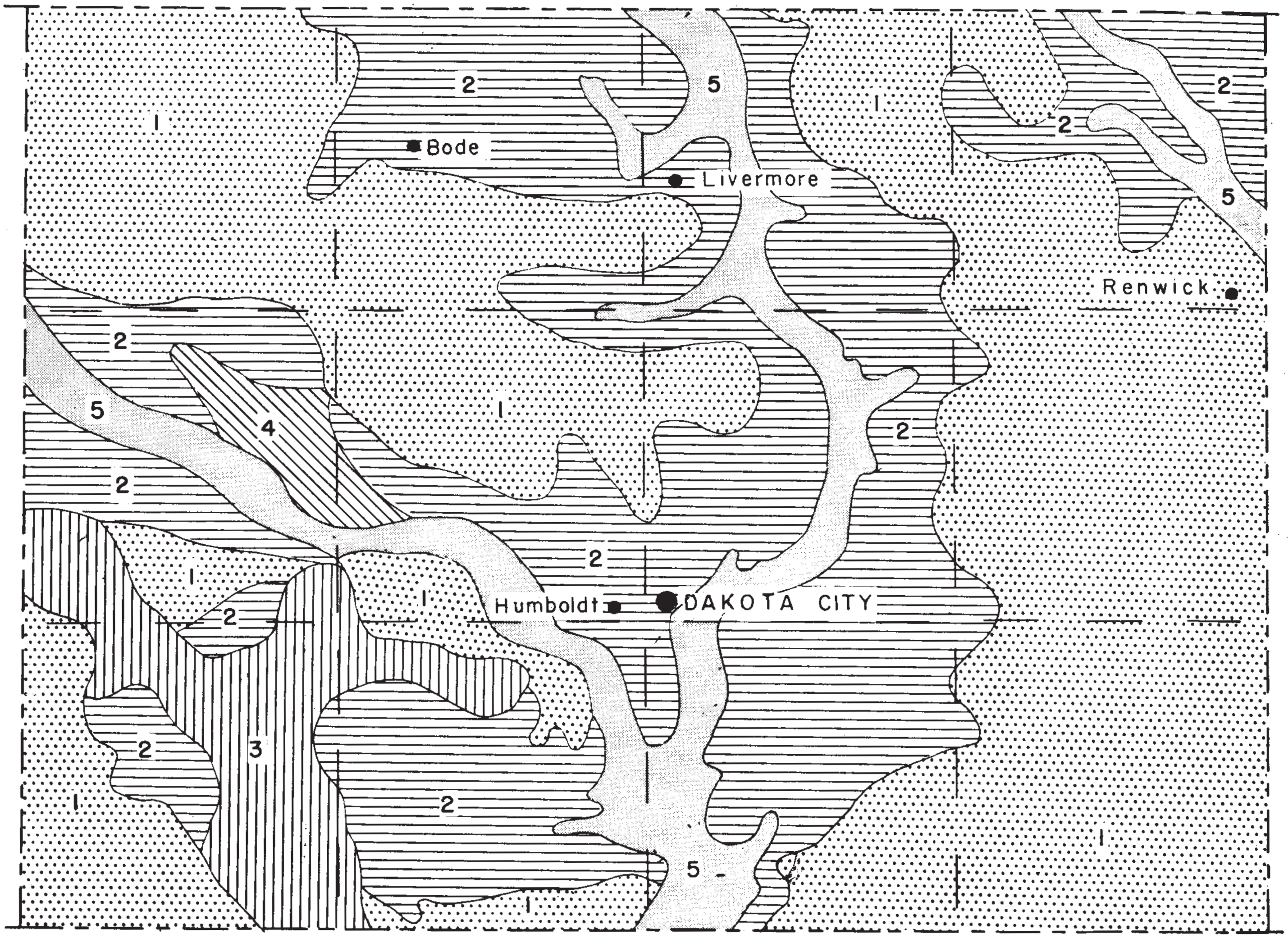

Figure 2.—General soil areas of Humboldt County. The principal soils in each area are the following: Area 1, Nicollet and Webster; area 2, Clarion and Webster; area 3, Clarion and Garmore; area 4, Waukegan and Kato; area 5, Waukegan and Huntsville.

AREA 4.—LEVEL TO UNDULATING SOILS ON SANDY OR GRAVELLY STREAM AND OUTWASH TERRACES: WAUKEGAN, KATO

The soils in this area are underlain by sand and gravel. The most extensive soils are the Waukegan, Kato, Marshan, and Dickinson, bench position. They vary in texture from sandy loam to silty clay loam. Some of the soils are droughty enough to limit yields, but others hold enough water for plant use and are very productive.

Figure 3.—A pothole soil covered with water after a heavy rain; Norway Township.

AREA 5.—LEVEL OR UNDULATING SOILS ON TERRACES OR BOTTOM LANDS: WAUKEGAN, HUNTSVILLE, AND OTHERS

In this area are the first and second bottoms of the Des Moines River and Prairie Creek. The Waukegan; Dickinson, bench position; Kato; and Marshan soils are on the second bottoms, or terraces. They are underlain by sand and gravel. The Huntsville, Colo, and Wabash soils are on the bottom lands and are sometimes flooded.

Soil Series and Mapping Units

This section describes the soil series and the mapping units in Humboldt County. For each series, there is a general description of the characteristics common to all soils in the series. This is followed by short descriptions of each of the soils in the series. The descriptions of the individual soils tell how each soil differs from the typical soil of the series and give some suggestions for use and management. Table 2 shows the acreage and proportionate extent of all the soils mapped. In table 3, p. 24, the major characteristics of the mapping units are summarized.

TABLE 2.—*Approximate acreage and proportionate extent of soils*

Symbol	Soil	Acreage	Percent
Ad	Alluvial land	3, 138	1. 1
Am	Ames loam	16	(1)
AnB	Ankeny sandy loam, 2 to 5 percent slopes	41	(1)
AnC	Ankeny sandy loam, 5 to 9 percent slopes	7	(1)
CaB	Clarion loam, 2 to 5 percent slopes	41, 162	14. 8
CaB2	Clarion loam, 2 to 5 percent slopes, moderately eroded	3, 870	1. 4
CaC	Clarion loam, 5 to 9 percent slopes	551	. 2
CaC2	Clarion loam, 5 to 9 percent slopes, moderately eroded	5, 116	1. 8
CaD2	Clarion loam, 9 to 15 percent slopes, moderately eroded	576	. 2
CaE2	Clarion loam, 15 to 20 percent slopes, moderately eroded	219	. 1
CaF2	Clarion loam, 20 to 30 percent slopes, moderately eroded	41	(1)
CaG	Clarion loam, 30 to 50 percent slopes	6	(1)
CnB	Clarion loam, thin solum, 2 to 5 percent slopes	575	. 2
CnC2	Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded	760	. 3
Co	Colo silt loam	642	. 2
Cp	Colo silt loam, channeled	443	. 2
Cr	Colo silty clay loam	1, 619	. 6
Cs	Colo silty clay loam, channeled	423	. 2
CtB	Colo-Terril complex, 1 to 5 percent slopes	1, 383	. 5
CtC	Colo-Terril complex, 5 to 9 percent slopes	10	(1)
Cu	Cullo silty clay loam	1, 603	. 6
Cv	Copas loam	459	. 2
DkA	Dickinson fine sandy loam, 0 to 2 percent slopes	76	(1)
DkB	Dickinson fine sandy loam, 2 to 5 percent slopes	461	. 2
DkC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded	118	(1)
DkD2	Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded	32	(1)
DkE3	Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded	37	(1)
DtA	Dickinson sandy loam, bench position, 0 to 2 percent slopes	1, 080	. 4
DtB	Dickinson sandy loam, bench position, 2 to 5 percent slopes	389	. 2
DtC2	Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded	51	(1)
DtD2	Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded	5	(1)
Du	Dundas silty clay loam	980	. 4
FaB	Farrar fine sandy loam, 2 to 5 percent slopes	314	. 1
FaC2	Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded	113	(1)
FaD2	Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded	61	(1)
Ga	Garmore silt loam	2, 237	. 8
Gc	Glencoe silty clay loam	7, 029	2. 5
Ha	Harpster loam	22, 086	7. 9
Hb	Harpster loam, sand and gravel substratum	2, 340	. 8
Hc	Harpster silt loam	4, 103	1. 5
HdB	Hayden loam, 2 to 5 percent slopes	284	. 1
HdC2	Hayden loam, 5 to 9 percent slopes, moderately eroded	54	(1)
HdD2	Hayden loam, 9 to 15 percent slopes, moderately eroded	11	(1)
HdE2	Hayden loam, 15 to 20 percent slopes, moderately eroded	26	(1)
HsF	Hayden soils, 20 to 50 percent slopes	319	0. 1
Hu	Huntsville silt loam	810	. 3
Hv	Huntsville silt loam, channeled	244	. 1
KdA	Kato loam, deep over sand and gravel, 0 to 2 percent slopes	2, 249	. 8
KdB	Kato loam, deep over sand and gravel, 2 to 5 percent slopes	389	. 2
KmA	Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes	474	. 2
KmB	Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes	106	(1)
LaC2	Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded	365	. 2
LaE2	Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded	114	(1)
LfB	Lamont fine sandy loam, 2 to 5 percent slopes	136	(1)
LfC2	Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded	108	(1)
LfD2	Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded	78	(1)
LfE2	Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded	60	(1)
LmB	Lester loam, 2 to 5 percent slopes	4, 156	1. 5
LmC2	Lester loam, 5 to 9 percent slopes, moderately eroded	1, 154	. 4
LmD2	Lester loam, 9 to 15 percent slopes, moderately eroded	405	. 2
LmE2	Lester loam, 15 to 20 percent slopes, moderately eroded	527	. 2
LsF	Lester soils, 20 to 30 percent slopes	636	. 2
LsG	Lester soils 30 to 50 percent slopes	603	. 2
Lu	LeSueur loam	2, 551	. 9
Md	Marshan silty clay loam, deep over sand and gravel	7, 647	2. 7
Mm	Marshan silty clay loam, moderately deep over sand and gravel	310	. 1
Mu	Muck, moderately shallow	806	. 3
Mw	Muck, shallow	2, 709	1. 0
Mx	Mucky peat, deep	77	(1)
My	Mucky peat, moderately shallow	923	. 3
Mz	Mucky peat, shallow	752	. 3
Nc	Nicollet loam	59, 878	21. 5
Ok	Okoboji silt loam	6, 941	2. 5
Op	Okoboji silt loam, imperfectly drained variant	119	(1)
Or	Orio fine sandy loam	124	(1)
Pv	Plattville loam	470	. 2
Ro	Rolfe loam	1, 992	. 7
SgB	Sogn loam, 2 to 5 percent slopes	156	. 1
StD2	Storden loam, 9 to 15 percent slopes, moderately eroded	253	. 1
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded	337	. 2
StF3	Storden loam, 20 to 30 percent slopes, severely eroded	165	. 1
StG3	Storden loam, 30 to 50 percent slopes, severely eroded	84	(1)
TeA	Terril loam, 0 to 2 percent slopes	80	(1)

1 Less than 0.1 percent.

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TABLE 2.—*Approximate acreage and proportionate extent of soils*—Continued

Symbol	Soil	Acreage	Percent
TeB	Terril loam, 2 to 5 percent slopes	1, 265	0. 5
TeC	Terril loam, 5 to 9 percent slopes	59	[1]
TrA	Truman silt loam, 0 to 2 percent slopes	743	. 3
TrB	Truman silt loam, 2 to 5 percent slopes	361	. 2
TrC2	Truman silt loam, 5 to 9 percent slopes, moderately eroded	65	[1]
TrD2	Truman silt loam, 9 to 15 percent slopes, moderately eroded	9	[1]
TrE2	Truman silt loam, 15 to 20 percent slopes, moderately eroded	9	[1]
Wa	Wabash silty clay	238	. 1
Wb	Wabash silty clay, channeled	7	[1]
Wc	Wacousta silt loam	1, 445	. 5
WdA	Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes	1, 622	. 6
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes	996	. 4
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded	107	[1]
WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes	1, 372	0. 5
WmB	Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes	1, 224	. 4
WmC2	Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded	204	. 1
WmD2	Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded	70	[1]
Wy	Webster silty clay loam	52, 291	18. 8
Wz	Webster silty clay loam, calcareous variant	11, 353	4. 1
Misc. land	Gravel pits and made land	1, 106	. 4
	Total	278, 400	100. 0

[1] Less than 0.1 percent.

Alluvial land

Alluvial land consists mostly of coarse-textured, recent stream deposits. It is frequently flooded. In most places it has a light-colored, sandy surface layer. The substratum is variable. The permeability and drainage are extremely variable. The water-holding capacity is variable; in many places it is low. The vegetation consists principally of willow brush and young trees.

Alluvial land (Ad).—Most of the Alluvial land in this county is on the flood plain of the Des Moines River. It is nearly level. There are several sandbars. Some areas have been cleared and are used for pasture.

Capability subclass Vw; management group 15.

Ames series

The Ames series consists of poorly drained soils that occur on the uplands, in small, nearly level areas and in depressions (fig. 4). Glacial till was the parent material, and trees were the native vegetation.

The following profile of Ames loam is representative of the Ames series.

Surface soil—
0 to 5 inches, dark-gray, moderately permeable loam.
Subsurface soil—
5 to 16 inches, gray, moderately permeable loam.
Subsoil—
16 to 52 inches, very dark gray and olive-gray, very slowly permeable, gritty silty clay loam to clay; olive-gray and brown mottles.
Parent material—
52 to 65 inches, brown, moderately permeable loam.

These soils are generally medium to low in available nitrogen, low in phosphorus, and low in potassium. The compact, clayey subsoil restricts the movement of air and water. The water-holding capacity is high.

Ames loam (Am).—If this soil is drained, it is suitable for cultivation. It responds to fertilizer but is only moderately productive. Because it occurs in small areas, most of it is cropped along with the surrounding soils. Some areas are used for trees or permanent pasture.

Unless drained, this soil may pond in years of above normal rainfall. Tile drains do not work well, but, since the areas are small, they are tiled along with the surrounding areas. Surface drains or open intakes leading to tile are needed in most places to remove surface water.

Capability subclass IIIw; management group 7.

Ankeny series

The Ankeny series consists of dark-colored, slightly droughty soils that occupy concave areas at the base of slopes. These soils developed from sandy material washed from the slopes. The principal native vegetation was prairie grasses.

The following profile of Ankeny sandy loam, on a slope of 3 percent, is representative of the series.

Surface soil—
0 to 26 inches, very dark brown, rapidly permeable sandy loam.
Subsoil—
26 to 45 inches, very dark grayish-brown, rapidly permeable sandy loam.
Parent material—
45 inches+, dark grayish-brown, rapidly permeable sandy loam.

These soils are somewhat excessively drained and have a low moisture-holding capacity. They are generally medium in available potassium and low in available nitrogen and phosphorus. They are erodible, but, because of their position at the base of slopes, they are more apt to accumulate sandy material than to erode.

Ankeny sandy loam, 2 to 5 percent slopes (AnB).—This soil is undulating. Water from the hillsides just above deposits new material on it. Diversion terraces on the slopes above may be needed to prevent further deposition, to prevent gullying, and to divert runoff. This soil is suitable for cultivation, and row crops are grown about half the time. The response to fertilizer is good, but, because of droughtiness, yields are only moderate.

Capability subclass IIs; management group 5.

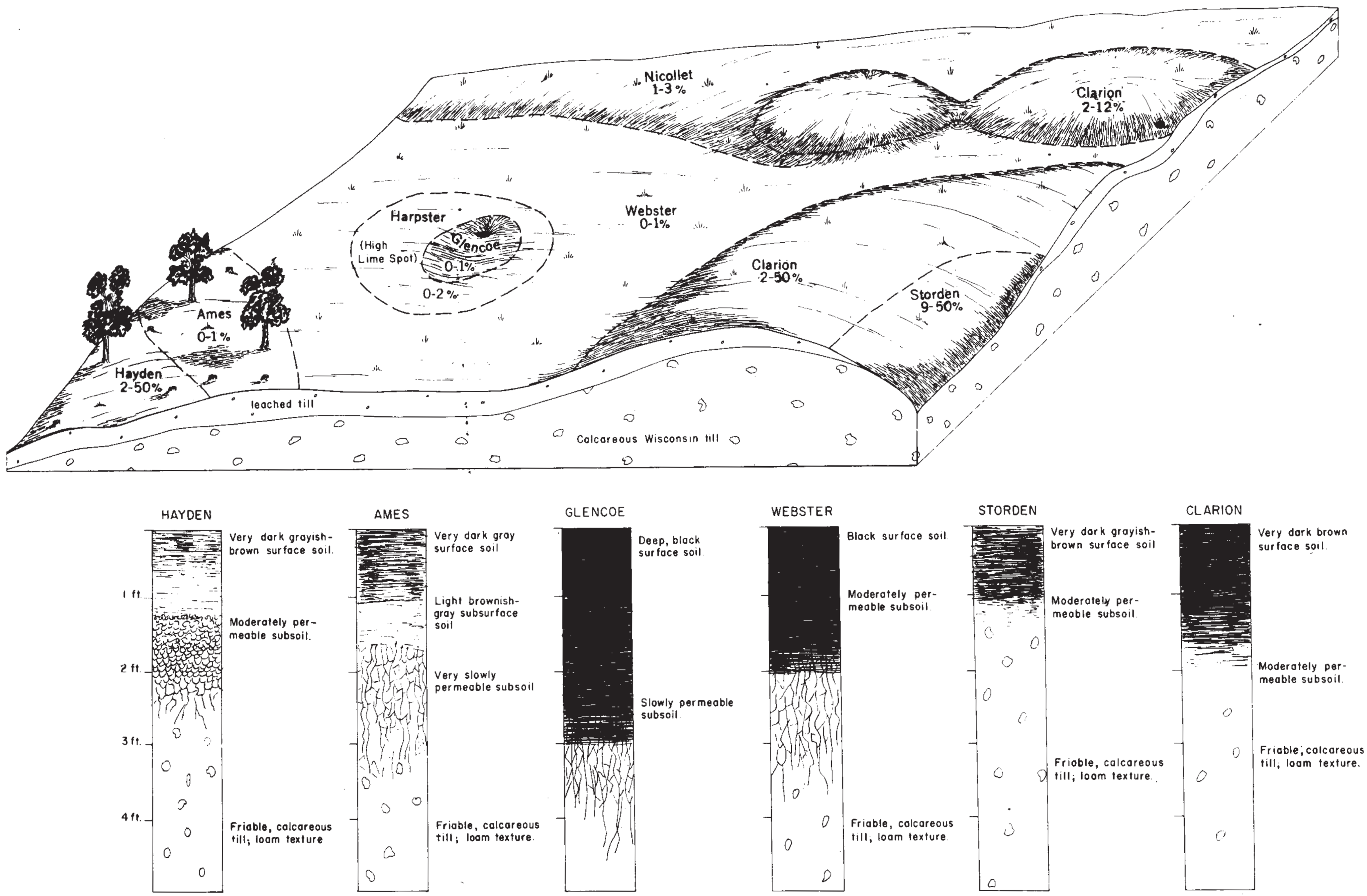

***Figure 4.*—Some upland soils in Humboldt County and their relation to one another. The native vegetation and parent material are indicated. The schematic soil profiles indicate the amount of organic matter, the thickness of the soil layers, and the permeability of the subsoil.**

Ankeny sandy loam, 5 to 9 percent slopes (AnC).—This soil is gently rolling. Although water from the adjoining hillsides deposits soil material on it, erosion may become active. Consequently, erosion control is needed if row crops are grown. Diversion terraces may have to be constructed on the slopes above to divert runoff and to prevent gullying and further deposition.

This soil is suitable for cultivation, but crop yields are limited by droughtiness.

Capability subclass IIIs; management group 10.

Clarion series

The Clarion series consists of well-drained soils that developed from calcareous glacial till. The native vegetation consisted of prairie grasses. These soils occur in both large and small areas on the uplands. The slopes are undulating to steep and, in many places, irregular. Generally, the undulating areas are away from the streams and the rolling to steep areas are adjacent to the streams. Figure 4, p. 9, shows how the Clarion soils occur in relation to other soils in the county.

The following profile of Clarion loam, on a slope of 3 percent, is representative of the series.

Surface soil—
- 0 to 8 inches, very dark brown, moderately permeable loam.

Subsoil—
- 8 to 26 inches, dark-brown, moderately permeable loam.

Parent material—
- 26 to 40 inches, dark yellowish-brown, moderately permeable loam.
- 40 inches+, yellowish-brown, moderately permeable, calcareous loam.

Small pockets of sand or gravel may occur in the subsoil or in the parent material.

The Clarion soils have a moderately high water-holding capacity. They are generally low in available nitrogen and phosphorus and medium in potassium. The need for lime is variable, but large amounts are not needed. All of these soils are subject to erosion.

Clarion loam, 2 to 5 percent slopes (CaB).—This soil responds to fertilizer and lime and is one of the most productive soils in the county. It is suitable for frequent row cropping (fig. 5). It is easy to work and, if well managed, fairly easy to keep in good tilth. There is a slight erosion hazard. The slopes are undulating and, in places, irregular. Contouring and terracing are difficult.

Capability subclass IIe; management group 6.

Figure 5.—**Corn, in mid-June, on a contoured and terraced field of Clarion loam, 2 to 5 percent slopes; section 19 of Grove Township.**

Clarion loam, 2 to 5 percent slopes, moderately eroded (CaB2).—The dark-colored surface layer of this soil is only 3 to 6 inches thick. The slopes are irregular and undulating. There is a slight erosion hazard.

This soil is highly productive, although it is somewhat lower in nitrogen than Clarion loam, 2 to 5 percent slopes. It is suitable for frequent row cropping if adequate erosion control practices are applied.

Capability subclass IIe; management group 6.

Clarion loam, 5 to 9 percent slopes (CaC).—This soil is highly productive. It has gently rolling slopes. It is suitable for frequent row cropping if erosion is controlled.

Capability subclass IIIe; management group 11.

Clarion loam, 5 to 9 percent slopes, moderately eroded (CaC2).—Only 3 to 6 inches of the original dark-colored surface layer of this soil remains. The slopes are gently rolling. The erosion hazard is moderate.

This soil needs more nitrogen fertilizer than the uneroded phases. It is highly productive and is suitable for frequent row cropping if contoured and terraced.

Capability subclass IIIe; management group 11.

Clarion loam, 9 to 15 percent slopes, moderately eroded (CaD2).—The dark-colored surface layer of this soil is only 3 to 6 inches thick. The slopes are rolling, and there is a severe erosion hazard.

This soil needs more nitrogen fertilizer than the uneroded phases. It is not suitable for intensive row cropping, because of the erosion hazard. It is moderately productive and can be used for row crops if contoured and terraced.

Capability subclass IIIe; management group 12.

Clarion loam, 15 to 20 percent slopes, moderately eroded (CaE2).—On this hilly soil, runoff is rapid and the erosion hazard is severe. The surface layer is only 3 to 6 inches thick and is not so dark colored as that in the representative profile.

This soil is suitable for only limited use for cultivated crops. It should be used for row crops no more often than about once in 6 years. The best use for it is semipermanent hay or pasture. If it is used for crops, it should be cultivated on the contour.

Capability subclass IVe; management group 14.

Clarion loam, 20 to 30 percent slopes, moderately eroded (CaF2).—The surface layer of this soil is only 3 to 6 inches thick, and it is not so dark colored as that in the representative profile described. The slopes are steep, and runoff is rapid.

This soil is not used for grain, because of the steep slopes. The best use for it is permanent pasture. In most places pasture renovation would increase production. Farm machinery can be used, but, because of the steep slopes, care is needed to prevent accidents.

Capability subclass VIe; management group 16.

Clarion loam, 30 to 50 percent slopes (CaG).—This soil is slightly eroded to severely eroded. The surface soil is thinner and lighter colored than that in the representative profile.

This soil is suitable for native pasture, as woodland, or as a habitat for wildlife. The very steep slopes make it unsuitable for grain and also prevent the use of ordinary farm machinery to renovate pastures.

Capability subclass VIIe; management group 18.

Clarion loam, thin solum, 2 to 5 percent slopes (CnB).—This soil is generally surrounded by other Clarion soils. It is only 12 to 24 inches deep over the calcareous glacial till. The slopes are irregular and undulating, and there is a slight erosion hazard.

This soil is highly productive and is suitable for frequent row cropping if erosion is controlled. It usually needs more phosphate than the normal Clarion soils because it is shallow over the calcareous material.

Capability subclass IIe; management group 6.

Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded (CnC2).—This soil is only 12 to 24 inches deep to calcareous glacial till. The dark-colored surface layer is only 3 to 6 inches thick. The slopes are gently rolling. There is a moderate erosion hazard.

This soil needs more nitrogen fertilizer than the uneroded Clarion soils. Because it is shallow over the calcareous material, it needs more phosphate than the normal Clarion soils. It is moderately productive and is suitable for frequent row cropping if contoured and terraced.

Capability subclass IIIe; management group 11.

Colo series

The Colo series consists of dark-colored, poorly drained, moderately slowly permeable, bottom-land soils that developed from alluvium. These soils are adjacent to streams and are nearly level to level. They are sometimes flooded in periods of high rainfall. The native vegetation consisted of prairie grasses, swamp grasses, and sedges.

The following profile of level Colo silt loam is representative of the Colo series.

Surface soil—
- 0 to 9 inches, very dark gray, moderately permeable silt loam.
- 9 to 16 inches, black, moderately permeable silt loam.

Subsoil—
- 16 to 36 inches, black, moderately slowly permeable silty clay loam.

Substratum—
- 36 to 55 inches, dark-gray, moderately permeable clay loam to loam.

The Colo soils have a very high water-holding capacity. They are generally medium in available nitrogen, phosphorus, and potassium.

Colo silt loam (Co).—This soil is flooded at variable intervals and usually receives a deposit of lighter colored, silty sediment when flooded. Artificial drainage by tile or open ditches is needed. Tile works well if outlets can be found, but frequently the water level in the streams is as high as the water level in the soil. There are a few old stream channels and oxbows. These are sometimes wetter than the rest of the soil, and they interfere with cultivation.

This soil responds to applications of fertilizer and is highly productive. Drained areas not subject to flooding can be row cropped intensively. Areas not suitable for cultivation are used for permanent pasture.

Capability subclass IIw; management group 2.

Colo silt loam, channeled (Cp).—This soil is frequently flooded and usually receives a deposit of lighter colored, silty sediment when flooded. It includes many old stream channels or oxbows that cannot be crossed with farm machinery. These channels are sometimes full of water. The soil in them is commonly very clayey.

This soil would be productive if it were drained and protected from floods and if the channels were filled. In its present condition, its best use is permanent pasture.

Capability subclass Vw; management group 15.

Colo silty clay loam (Cr).—This soil has a black surface layer. The texture, to a depth of about 50 inches, is silty clay loam. There are a few old stream channels and oxbows. These are wetter than the rest of the soil and may interfere with cultivation. The frequency of flooding is variable.

This soil is highly productive. It can be row cropped intensively, provided it can be drained and protected from flooding. Areas not suitable for cultivation are used for permanent pasture.

Capability subclass IIw; management group 2.

Colo silty clay loam, channeled (Cs).—This soil is frequently flooded. The texture is silty clay loam to a depth of about 50 inches. The surface layer is black. There are many old stream channels and oxbows that cannot be crossed with farm machinery. These channels are sometimes filled with water. The soil in them is commonly silty clay or clay.

This soil would be productive if it were drained and protected from floods and if the channels were filled. At present, it is best used for permanent pasture.

Capability subclass Vw; management group 15.

Colo-Terril complex, 1 to 5 percent slopes (CtB).—In narrow drainageways near streams, Colo and Terril soils are so closely associated that they are not mapped separately. The Colo soils are near the drainageways, and the Terril soils are at the base of the adjacent slopes. The drainage ranges from good to poor, and the permeability ranges from moderate to moderately slow.

Because they occur in narrow areas, these soils are usually cropped along with the adjacent soils. They are moderately productive if drained and protected from runoff. Many of the areas are used for permanent pasture.

Drainage and erosion control are the principal management problems. The areas near the drainageways are usually too wet for cultivation unless they are drained by tile. Gullies tend to form where water accumulates. Grassed waterways are needed in many places. Minor floods occur during periods of high rainfall. Diversions are needed to protect cultivated areas from runoff.

Capability subclass IIw; management group 3.

Colo-Terril complex, 5 to 9 percent slopes (CtC).—This complex contains proportionately more Terril soil than does Colo-Terril complex, 1 to 5 percent slopes.

Because they occur in narrow areas, these soils are usually cropped along with the adjacent soils. They are moderately productive. The areas near drainageways are not suitable for cultivation unless artificially drained. On the side slopes, erosion is a problem. Gullies tend to form where water flows. Grassed waterways are needed in many places to control erosion. Diversions are needed to protect cultivated areas from runoff.

Capability subclass IIIe; management group 11.

Copas series [4]

The Copas series consists of nearly level, dark-colored, well-drained soils that are underlain by limestone bedrock at depths of 18 to 30 inches. These soils are in upland drainageways or on terraces along major streams.[5] They are sometimes flooded in periods of high rainfall. They formed from alluvium or glacial outwash material. The principal native vegetation was prairie grasses.

The following profile of Copas loam is representative of the Copas series.

Surface soil—
0 to 11 inches, very dark gray loam; moderately rapid permeability.
Subsoil—
11 to 22 inches, dark-brown and dark yellowish-brown loam.
Substratum—
22 inches+, limestone bedrock.

These soils are slightly droughty. They have moderately rapid permeability and a low moisture-holding capacity. They are generally low in available nitrogen, low in available phosphorus, and medium to low in available potassium. They are neutral to medium acid.

Copas loam (Cv).—This soil has practically no erosion hazard, but it is droughty and consequently is not suited to intensive use for cultivated crops. The severity of the droughtiness depends on the depth to bedrock.

This soil responds to fertilizer, but because of the droughtiness it would be uneconomical to apply large amounts of fertilizer. Crop yields are low.

Capability subclass IIs; management group 5.

Cullo series

The Cullo series consists of dark-colored, nearly level, poorly drained soils that developed from waterworked glacial till or local alluvium. These soils are in slight depressions but are not rimmed by Harpster soils, as are the Glencoe soils, which occur in a similar position. The native vegetation consisted of swamp grasses and sedges.

The following profile of Cullo silty clay loam is representative of the Cullo series.

Surface soil—
0 to 13 inches, black, moderately slowly permeable silty clay loam.
Subsurface soil—
13 to 16 inches, very dark gray and dark gray, moderately permeable silt loam.
Subsoil—
16 to 35 inches, olive-gray, slowly permeable, heavy silty clay loam; olive and olive-gray mottles.
Parent material—
35 to 50 inches, dark-gray, moderately permeable loam; olive mottles.

These soils are generally medium in available nitrogen and potassium and low in available phosphorus. The water-holding capacity is high. The permeability is slow. The subsoil somewhat restricts the movement of air and water.

Unless artificially drained, these soils are sometimes ponded. Tile drains work fairly well.

Cullo silty clay loam (Cu).—If drained, this soil is suitable for frequent row cropping. It responds to fertilizer and is moderately productive. If well managed, it can be kept in good tilth. Removing excess water and maintaining fertility are the principal management problems.

Very small areas of this soil are shown on the soil map by conventional symbols.

Capability subclass IIIw; management group 7.

Dickinson series

The Dickinson series consists of sandy, dark-colored, excessively drained, nearly level to hilly soils on uplands or terraces. These soils developed from sandy material. The native vegetation consisted of prairie grasses.

The following profile of Dickinson fine sandy loam, on a slope of 3 percent, is representative of the Dickinson series.

Surface soil—
0 to 10 inches, very dark gray fine sandy loam; moderately rapid permeability.
Subsoil—
10 to 30 inches, dark-brown sandy loam; moderately rapid permeability.
Parent material—
30 inches+, yellowish-brown loamy sand and sand; rapid permeability.

In eroded areas the surface soil is not so dark colored.

Dickinson soils have rapid to moderately rapid permeability and a low water-holding capacity. They are generally low in available nitrogen, phosphorus, and potassium. Lime needs are variable.

Dickinson fine sandy loam, 0 to 2 percent slopes (DkA).—The parent material of this soil was mostly wind-deposited sandy material but included some sandy glacial drift. The profile is like the representative profile, except that the dark-colored surface layer is 10 to 14 inches thick.

This soil is suitable for cultivated crops. It responds to fertilizer but, because of droughtiness, produces only moderate yields. Wind erosion is a hazard. Blowing sand damages young plants in some years.

Capability subclass IIIs; management group 9.

Dickinson fine sandy loam, 2 to 5 percent slopes (DkB).—This soil is undulating and is subject to erosion by both wind and water. It is suitable for cultivated crops. Because of droughtiness, crop yields are only moderate.

Capability subclass IIIs; management group 9.

Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded (DkC2).—The profile of this soil is like the representative profile, except for erosion. Only 3 to 6 inches of the original surface soil remains. The slopes are gently rolling.

This soil is subject to both wind and water erosion. It is suitable for limited use for cultivated crops if it is contoured or terraced. However, because of droughtiness, it is probably best used for permanent hay or pasture.

Capability subclass IVs; management group 13.

Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded (DkD2).—The surface layer of this soil is only 3 to 6 inches thick. The slopes are rolling.

This soil is not suitable for cultivated crops, because it is droughty and is subject to both wind and water erosion. It is best for permanent pasture.

Capability subclass VIs; management group 17.

[4] The Copas soils described in this report are now considered to be within the range of the Rockton series.

[5] The occurrence of Copas soils in this topographic position is peculiar to Humboldt County. These soils are not restricted to this kind of topography.

Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded (DkE3).—The surface layer of this hilly soil is less than 6 inches thick. Otherwise, the profile is like the representative profile.

This soil is best used for permanent pasture. It is not suitable for cultivated crops, because of droughtiness, strong slopes, and the hazard of wind and water erosion.

Some moderately eroded soil is included.

Capability subclass VIs; management group 17.

Dickinson sandy loam, bench position, 0 to 2 percent slopes (DtA).—This soil developed from sandy material deposited by water on nearly level stream terraces. The dark-colored surface layer is 7 to 14 inches thick, and the underlying material includes strata of gravel as well as sand.

This soil can be used for cultivated crops, but yields are low because of droughtiness. Cultivated areas are subject to wind erosion.

Capability subclass IIIs; management group 9.

Dickinson sandy loam, bench position, 2 to 5 percent slopes (DtB).—This soil is like Dickinson sandy loam, bench position, 0 to 2 percent slopes, except that it has undulating slopes. It is suitable for limited use for cultivated crops. Crop yields are low because of droughtiness. Cultivated areas are subject to both wind and water erosion.

Capability subclass IIIs; management group 9.

Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded (DtC2).—This soil is like Dickinson sandy loam, bench position, 0 to 2 percent slopes, except that it has rolling slopes and the dark-colored surface layer is only 3 to 6 inches thick. It can be used for cultivated crops, but crop yields are very low because of droughtiness. Probably the best use for it is permanent hay or pasture. Cultivated areas are subject to both wind and water erosion.

Capability subclass IVs; management group 13.

Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded (DtD2).—This soil is like Dickinson sandy loam, bench position, 0 to 2 percent slopes, except that it has rolling slopes and the surface layer is less than 6 inches thick. It is not suitable for cultivated crops, because it is very droughty and very low in productivity and erodes easily. Permanent pasture is the best use for it.

Capability subclass VIs; management group 17.

Dundas series

The Dundas series consists of dark-colored, poorly drained soils that developed from glacial till. These soils occur in rather small, nearly level areas in the uplands near woods. The native vegetation consisted of prairie grasses and trees.

The following profile of Dundas silty clay loam is representative of the Dundas series.

Surface soil—
0 to 8 inches, black, moderately slowly permeable silty clay loam.
Subsurface soil—
8 to 13 inches, dark-gray, slowly permeable silty clay loam.
Subsoil—
13 to 39 inches, dark grayish-brown and dark-gray, very slowly permeable, gritty silty clay to heavy silty clay loam.
Parent material—
39 to 45 inches, grayish-brown, moderately permeable loam.

The Dundas soils are medium acid to strongly acid. They are generally low in available nitrogen and medium in available phosphorus and potassium. The water-holding capacity is high, and the permeability is slow to very slow. The clay in the subsoil restricts the movement of air and water.

Dundas silty clay loam (Du).—If this soil is drained, it is suitable for frequent row cropping. It is highly productive. Because it occurs in rather small areas, it is ordinarily cropped along with the surrounding soils. Some areas are still in forest.

This soil responds to applications of fertilizer. Under a high level of management, good tilth is easy to maintain. The chief management problems are drainage and maintenance of fertility.

Capability subclass IIw; management group 3.

Farrar series

The Farrar series consists of undulating to rolling, somewhat excessively drained sandy soils of the uplands. These soils developed in sandy, wind-deposited material that is 14 to 40 inches thick over glacial till. They are moderately dark colored where not eroded. The native vegetation consisted of prairie grasses. The following profile of Farrar fine sandy loam, on a slope of 3 percent, is representative of the Farrar series.

Surface soil—
0 to 12 inches, very dark grayish-brown to dark-brown, moderately rapidly permeable fine sandy loam.
Subsoil—
12 to 24 inches, dark yellowish-brown, moderately rapidly permeable sandy loam.
Substratum—
24 inches+, yellowish-brown, moderately permeable loam (till).

The Farrar soils are generally low in available nitrogen and phosphorus and medium in available potassium. They are slightly droughty and have a low moisture-holding capacity. Wind erosion is severe at times.

Farrar fine sandy loam, 2 to 5 percent slopes (FaB).—This soil is undulating and has a slight erosion hazard. It is slightly droughty, even in seasons of normal rainfall. It is easy to work and is suitable for cultivated crops, but yields are not high. Blowing sand sometimes damages young plants. Leaving crop residues on the surface will reduce wind damage. The soil responds favorably to applications of complete fertilizer.

Capability subclass IIs; management group 5.

Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded (FaC2).—This soil is gently rolling and has a moderate erosion hazard. It has a surface layer that is only 3 to 6 inches thick. It is droughty, even in seasons of normal rainfall. It can be used for row crops, but yields are not high. If row cropped, it should be contoured and terraced.

Capability subclass IIIs; management group 10.

Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded (FaD2).—This soil is rolling and has a severe erosion hazard. The surface layer is only 3 to 6 inches thick. The soil is droughty, even in seasons of normal rainfall. Its use for grain is limited. Permanent hay is probably the best use for it.

Capability subclass IVs; management group 13.

Garmore series

The Garmore series consists of moderately well drained, dark-colored soils that developed from glacial till. Soils of this series occur in general soil area 3 in the southwestern part of the county. The slopes are both concave and convex and are nearly level to undulating. The native vegetation consisted of prairie grasses. The following profile of Garmore silt loam, on a slope of 2 percent, is representative of the Garmore series.

Surface soil—
- 0 to 15 inches, black to very dark gray, moderately permeable silt loam.

Subsoil—
- 15 to 49 inches, dark grayish-brown and dark-brown, moderately permeable clay loam; very dark gray mottles.

Parent material—
- 49 to 75 inches, yellowish-brown, moderately permeable loam; calcareous below a depth of 62 inches; limestone bedrock at a depth of 14 feet.

The Garmore soils are generally low in available nitrogen and phosphorus and medium in available potassium. They are strongly acid. They have a high water-holding capacity.

Garmore silt loam (Ga).—This is one of the most productive soils in the county. It is suitable for frequent row cropping. On intensively cultivated slopes of 2 to 3 percent, it has a very slight erosion hazard. It is seldom, if ever, too wet for crops, and it seldom, if ever, needs tile drainage.

Capability class I; management group 1.

Glencoe series

The Glencoe series consists of very dark colored, pothole soils that are very poorly drained. These soils are nearly level and occur in depressions in the uplands. Unless they are drained, they are often ponded. The parent material was waterworked glacial till or local alluvium. Swamp grasses and sedges were the native vegetation. The Glencoe soils are generally rimmed with Harpster soils (see fig. 4, page 9). The following profile of Glencoe silty clay loam is representative of the Glencoe series.

Surface soil—
- 0 to 20 inches, black, slowly permeable silty clay loam.

Subsoil—
- 20 to 49 inches, black to very dark gray, slowly to very slowly permeable, light silty clay to silty clay loam.

Parent material—
- 49 to 56 inches, gray to light-gray, moderately slowly permeable, calcareous, heavy silt loam or loam.

Normally the Glencoe soils are medium to high in available nitrogen and medium in available phosphorus and potassium. They have a very high water-holding capacity.

Glencoe silty clay loam (Gc).—This soil is suitable for frequent row cropping if excellent artificial drainage is provided. After heavy rains, crops are often drowned out unless surface water is removed by open intakes leading to tile or by shallow surface drains. Because of the slow to very slow permeability of the soil, tile drains are only fairly effective. They should be placed closer together than in the Webster soils. In many places it is difficult to place the outlets deep enough to drain properly.

This soil seldom needs lime. Phosphate and potash fertilizers should be applied if the best yields are to be obtained. Yields are high in the drier years, but yields averaged over a long period are only moderate. This soil occurs in small areas and is usually cropped along with the surrounding soils. Very small areas are shown on the soil map by conventional symbols.

Capability subclass IIIw; management group 7.

Harpster series

The Harpster series consists of nearly level, poorly drained soils that have developed from glacial till, outwash, or alluvium. These soils are high in lime. When they are dry, the surface color in cultivated fields is distinctly grayer than the color of the surrounding soils. The native vegetation consisted of prairie grasses. The following profile of Harpster loam, on a slope of 1 percent, is representative of the Harpster series.

Surface soil—
- 0 to 9 inches, dark-gray, moderately permeable loam; very high in lime.

Subsoil—
- 9 to 22 inches, dark-gray to grayish-brown, moderately slowly permeable clay loam; very high in lime.

Parent material—
- 22 to 60 inches, olive-gray to grayish-brown, moderately permeable loam; very high in lime.

The Harpster soils are generally medium in available nitrogen and very low in available phosphorus and potassium. Some areas are deficient in iron and other minor elements.

Harpster loam (Ha).—This soil occurs as a rim around potholes and depressions in the uplands (see fig. 4, p. 9) or as a low rise within a pothole or depression. There is a serious potassium deficiency for most crops grown on this soil. Corn yields may be 20 to 30 bushels per acre lower than those from the surrounding soils, unless enough fertilizer is applied to correct the extreme deficiences in phosphorus and potassium. Many areas do not supply enough iron for soybeans.

This soil is suitable for frequent row cropping if properly drained and fertilized. Tile drainage is needed. Unless this soil is artificially drained, it is often too wet to be cultivated. The response to potash and phosphate fertilizers is good. Lime should not be applied.

Most areas of this soil are small and are cropped along with the surrounding soils. Very small areas are shown on the soil map by conventional symbols.

Capability subclass IIw; management group 4.

Harpster loam, sand and gravel substratum (Hb).—This soil has a sandy or gravelly substratum below depths of 30 to 50 inches. It occurs on stream terraces and on beaches around former lakes. It is seriously deficient in potassium for most crops. Corn yields may be 20 to 30 bushels per acre lower than on the surrounding soil unless enough fertilizer is applied to correct the deficiencies in phosphorus and potassium.

This soil is suitable for frequent row cropping if properly drained and fertilized. The response to potash and phosphate fertilizers is good. Most areas are small and are cropped along with the surrounding soils.

Capability subclass IIw; management group 4.

Harpster silt loam (Hc).—This soil differs from that described as representative of the series in being silt loam throughout. It is nearly level and occurs in fairly large areas on stream terraces. It is moderately permeable. It is seriously deficient in potassium for most crops. Corn yields may be 15 to 20 bushels lower than on the surrounding soils unless enough fertilizer is applied to correct the phosphorus and potassium deficiencies.

This soil is suitable for frequent row cropping if properly drained and fertilized. It responds well to applications of phosphate and potash. Yields are moderate.

Capability subclass IIw; management group 4.

Hayden series

These are well-drained, moderately dark colored to light colored, upland soils developed from glacial till. The slopes range from undulating to steep. These soils generally occur along streams near timbered areas. Figure 4, p. 9, shows how the Hayden soils occur in relationship to other soils. Hardwoods were the native vegetation. A few sand and gravel spots may occur. Representative of the Hayden series is the following profile of Hayden loam, on a slope of 3 percent.

Surface soil—
- 0 to 5 inches, very dark gray, moderately permeable loam.

Subsurface soil—
- 5 to 9 inches, dark grayish-brown, moderately permeable loam.

Subsoil—
- 9 to 38 inches, dark-brown, moderately slowly permeable loam to clay loam.

Parent material—
- 38 to 50 inches, yellowish-brown, moderately permeable loam.

Generally, the Hayden soils are low in available nitrogen and phosphorus and medium in potassium. They are medium acid. They have a moderately high water-holding capacity.

Hayden loam, 2 to 5 percent slopes (HdB).—This undulating soil is highly productive and is suitable for frequent row cropping if measures are taken to control erosion. It is lighter colored than the Clarion soils and is lower in nitrogen. Under a high level of management, it is easy to keep in good tilth. The response to fertilizer is good.

Capability subclass IIe; management group 6.

Hayden loam, 5 to 9 percent slopes, moderately eroded (HdC2).—This gently rolling soil is like that described for the series except that, in most places, the combined thickness of the surface and subsurface layers is only 3 to 6 inches. A few areas are included that have a thicker surface soil. There is a moderate erosion hazard. This soil can be used frequently for row crops if contoured and terraced. It is moderately productive.

Capability subclass IIIe; management group 11.

Hayden loam, 9 to 15 percent slopes, moderately eroded (HdD2).—The profile of this soil is like that described as representative of the series, except that, in most places, the combined thickness of the surface and subsurface layers is only 3 to 6 inches. A few areas are included where less than 3 inches of the original surface soil remains. The slopes are rolling, and there is a severe erosion hazard if this soil is cultivated. It should be contoured or terraced if row crops are grown. Yields are only moderate.

Capability subclass IIIe; management group 12.

Hayden loam, 15 to 20 percent slopes, moderately eroded (HdE2).—This hilly soil has a severe erosion hazard. Its surface layer is only 3 to 6 inches thick. The strong slopes are poorly suited to row crops. The best use is probably semipermanent hay or pasture. Row crops should be grown only occasionally. This soil is suitable for producing timber.

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Capability subclass IVe; management group 14.

Hayden soils, 20 to 50 percent slopes (HsF).—This soil has steep slopes and a severe erosion hazard. The surface layer is only 3 to 6 inches thick. The soil is too steep for cultivation and it is best for permanent pasture, as woodland, or as a habitat for wildlife.

Capability subclass VIIe; management group 18.

Huntsville series

The Huntsville series consists of dark-colored, bottomland soils that are imperfectly drained. These soils are nearly level and are flooded in periods of heavy rainfall, which come most often in spring. The native vegetation was a mixture of prairie grasses and trees. The following profile of Huntsville silt loam is representative of the series.

Surface soil—
- 0 to 19 inches, very dark gray, moderately permeable silt loam.

Subsoil—
- 19 to 44 inches, light olive-brown, moderately permeable silty clay loam to clay loam.

Substratum—
- 44 to 60 inches, light olive-brown and grayish-brown, moderately rapidly permeable sandy loam.

The Huntsville soils have a medium to high water-holding capacity. They are moderately permeable. Normally, they are medium in available nitrogen and potassium and low in available phosphorus.

Huntsville silt loam, channeled (Hv).—This soil is frequently flooded. Its use is limited to permanent hay or pasture. There are oxbows and old stream channels that are not crossable with farm machinery. Sometimes the oxbows and channels are filled with water, and in many of them the soil is very clayey.

Capability subclass Vw; management group 15.

Huntsville silt loam (Hu).—This soil is flooded less often than Huntsville silt loam, channeled. If floods are controlled, it is highly productive and is suitable for frequent row cropping. It responds to applications of complete fertilizer but seldom needs lime. Under a high level of management, good tilth is easy to maintain.

Capability subclass IIw; management group 2.

Kato series

The Kato series consists of dark-colored, imperfectly drained soils that are underlain by sand or gravel at depths of 2 feet or more. These soils are nearly level to undulating. They occur on outwash terraces along streams. Most areas are large. The native vegetation consisted principally of prairie grasses.

A representative profile of Kato loam, moderately deep over sand and gravel, on a slope of 1 percent, is described as follows.

Surface soil—
- 0 to 15 inches, black, moderately permeable loam.

Subsoil—
- 15 to 28 inches, very dark grayish-brown, moderately permeable clay loam to sandy clay loam; dark-brown and very dark gray mottles.

Substratum—
- 28 to 50 inches, light olive-brown to yellowish-brown, calcareous sand and gravel.

The Kato soils are generally medium in available nitrogen, phosphorus, and potassium.

Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes (KmA).—The profile of this soil is like the representative profile described. Generally, the depth to sand and gravel is 24 to 30 inches. This soil is slightly wet in rainy seasons and slightly droughty in others. It seldom needs tile drainage. Tile installation may be difficult because of caving. This soil is suitable for frequent row cropping, but, because it is slightly droughty, is only moderately productive. It responds to applications of complete fertiiizer. Erosion is not a problem.

Capability subclass IIs; management group 5.

Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes (KmB).—The surface layer of this soil is only 7 to 14 inches thick. In most places, the depth to sand and gravel is 24 to 30 inches. This soil is gently undulating and has a slight erosion hazard. In seasons of low rainfall it tends to be droughty. It is seldom too wet for crops and is suitable for frequent row cropping. The average yields are only moderate, because of droughtiness.

Capability subclass IIs; management group 5.

Kato loam, deep over sand and gravel, 0 to 2 percent slopes (KdA).—The profile of this soil is similar to that described as representative of the series. The depth to sand and gravel is variable but is more than 3 feet. In periods of high rainfall there may be a slight drainage problem. Tile may be hard to install because of cave-ins.

This soil is suitable for frequent row cropping and is among the most productive soils in the county.

Capability class I; management group 1.

Kato loam, deep over sand and gravel, 2 to 5 percent slopes (KdB).—The surface layer of this soil is 7 to 14 inches thick. The depth to sand and gravel is variable but is more than 36 inches. This soil is undulating and has a slight erosion hazard. It is slightly wet in periods of above normal rainfall. It is suitable for frequent row cropping and is among the most productive soils in the county.

Capability subclass IIe; management group 6.

Lakeville series

The Lakeville series consists of moderately dark colored, very droughty soils underlain by gravel. These soils are gently rolling to hilly. They occur on gravelly knobs in the uplands. There are many gravel pits. The native vegetation consisted of prairie grasses. The following profile of Lakeville gravelly loam, on a slope of 7 percent, is representative of the series.

Surface soil—
- 0 to 7 inches, dark-brown, rapidly permeable gravelly loam or sandy loam.

Substratum—
- 7 inches+, yellowish-brown, very rapidly permeable, loose, calcareous gravel.

Normally, the Lakeville soils are low in available nitrogen, phosphorus, and potassium. In most areas they are high in lime. They are excessively drained and have a very low water-holding capacity. The degree of droughtiness varies with the texture of the substratum, which, within short distances, ranges from gravel to gravelly loam.

Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded (LaC2).—Most of this soil is gently rolling, but some milder slopes are included. If this soil is cultivated, it has a moderate hazard of both wind and water erosion. It is very droughty; consequently, it does not respond well to applications of fertilizer. Its best use is permanent hay or pasture.

Capability subclass IVs; management group 13.

Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded (LaE2).—This soil is rolling to hilly. If it is cultivated, it is subject to severe erosion by wind and water. Because of extreme droughtiness, its best use is permanent pasture.

Capability subclass VIs; management group 17.

Lamont series

The Lamont series consists of slightly droughty, moderately dark colored to light colored soils that developed from wind-deposited sands. They are subject to erosion by both wind and water. They occur mainly on the east side of the East Fork Des Moines River. The convex slopes are undulating to hilly. Trees were the native vegetation. Most areas are now in woodland pasture. The following profile of Lamont fine sandy loam, on a slope of 7 percent, is representative of the series.

Surface soil—
- 0 to 7 inches, very dark brown fine sandy loam.

Subsurface soil—
- 7 to 16 inches, dark grayish-brown fine sandy loam.

Subsoil—
- 16 to 36 inches, dark-brown sandy loam to sandy clay loam.

Parent material—
- 36 to 60 inches, dark-brown loamy sand.

The Lamont soils are excessively drained. They have moderately rapid permeability and a low water-holding capacity. Normally, they are low in available nitrogen, phosphorus, and potassium and low in lime.

Lamont fine sandy loam, 2 to 5 percent slopes (LfB).—This undulating soil has a slight erosion hazard. Crop residues should be left on the surface to reduce wind erosion and prevent damage to young plants by blowing sand. Even in seasons of normal rainfall, this soil is droughty; consequently, its suitability for cultivated crops is limited. Yields are low. This soil responds well to applications of lime and complete fertilizer, but heavy applications are not economical.

Capability subclass IIs; management group 5.

Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded (LfC2).—This soil has a thinner surface layer than that in the representative profile. It has gently rolling slopes and a moderate erosion hazard. It is droughty even in seasons of normal rainfall; therefore, it is suitable for only limited use for cultivated crops. Average yields are low.

Capability subclass IIIs; management group 10.

Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded (LfD2).—This soil has a thinner and lighter colored surface layer than the representative profile. It has rolling slopes and a severe erosion hazard. It is droughty even in seasons of normal rainfall and, therefore, is not suitable for cultivated crops. It is best used for permanent hay, pasture, or woodland.

Capability subclass IVs; management group 13.

Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded (LfE2).—The surface layer of this soil is thinner and lighter colored than the one described in the representative profile. The slopes are hilly, and the erosion hazard is severe. This soil is droughty even in periods of normal rainfall. It is best used for permanent pasture, as woodland, or as a wildlife habitat.

Capability subclass VIs; management group 17.

Lester series

The Lester series consists of well-drained, undulating to steep, upland soils that developed from glacial till. These soils are moderately dark colored. They occur in fairly large areas. All are subject to erosion. The stronger the slope, the greater the erosion hazard. The native vegetation was a mixture of trees and prairie grasses. The following profile of Lester loam, on a slope of 3 percent, is representative of the series.

Surface soil—
 0 to 7 inches, very dark grayish-brown, moderately permeable loam.
Subsurface soil—
 7 to 9 inches, dark grayish-brown, moderately permeable loam.
Subsoil—
 9 to 35 inches, dark-brown to dark yellowish-brown, moderately permeable light clay loam to heavy loam.
Parent material—
 35 inches+, yellowish-brown to light yellowish-brown, moderately permeable, calcareous loam.

The Lester soils are normally low in available nitrogen and phosphorus and medium in available potassium. They have a high water-holding capacity.

Lester loam, 2 to 5 percent slopes (LmB).—This soil is undulating and has a slight erosion hazard. It is suitable for frequent row cropping and is highly productive (fig. 6). The response to fertilizers is good.

Capability subclass IIe; management group 6.

Lester loam, 5 to 9 percent slopes, moderately eroded (LmC2).—This soil has a surface layer that is only 3 to 6 inches thick. It is gently rolling and has a moderate erosion hazard. It is suitable for frequent row cropping if contoured or terraced. Yields are moderate.

Capability subclass IIIe; management group 11.

Figure 6.—**Meadow of alfalfa, bromegrass, and orchardgrass on Lester loam, 2 to 5 percent slopes; section 12 of Corinth Township. Although this soil is ordinarily used for corn, it also produces excellent forage crops.**

Lester loam, 9 to 15 percent slopes, moderately eroded (LmD2).—This soil has a surface layer that is only 3 to 6 inches thick. It is rolling and has a severe erosion hazard. It should be contoured or terraced when used for row crops. It is suitable for cultivated crops, but average yields are only moderate.

Capability subclass IIIe; management group 12.

Lester loam, 15 to 20 percent slopes, moderately eroded (LmE2).—This soil has a surface layer that is only 3 to 6 inches thick. It is hilly and has a severe erosion hazard. Because of the strong slopes, this soil is of limited use for cultivated crops. It is best for permanent hay.

Capability subclass IVe; management group 14.

Lester soils, 20 to 30 percent slopes (LsF).—These soils have a surface layer that is only 3 to 6 inches thick. The erosion hazard is severe. The soils are best for permanent pasture or woodland. Although the slopes are steep, farm machinery can probably be used for pasture renovation if care is taken to avoid accidents.

Capability subclass VIe; management group 16.

Lester soils, 30 to 50 percent slopes (LsG).—The surface layer of these soils is only 3 to 6 inches thick. The slopes are too steep for operation of any of the ordinary farm machinery, and, therefore, pasture improvement is very difficult. These soils are suitable for woodland or permanent pasture.

Capability subclass VIIe; management group 18.

LeSueur series

In the LeSueur series are imperfectly drained, dark-colored, upland soils that developed from glacial till. They occur on nearly level slopes in hilly areas that are adjacent to the major streams. The slopes range from ½ to 3 percent. The native vegetation was a mixture of trees and prairie grasses. The following profile of LeSueur loam, on a slope of 2 percent, is representative of the series.

Surface soil—
 0 to 6 inches, black, moderately permeable loam.
Subsurface soil—
 6 to 10 inches, very dark gray, moderately permeable loam.
Subsoil—
 10 to 34 inches, dark grayish-brown and very dark grayish-brown, moderately to moderately slowly permeable clay loam; strong-brown mottles.
Parent material—
 34 to 50 inches, grayish-brown and dark grayish-brown, moderately permeable loam.

The LeSueur soils are generally low in available nitrogen and phosphorus and medium in available potassium. They are slightly acid. They have a high water-holding capacity.

LeSueur loam (Lu).—This soil is suitable for frequent row cropping and is highly productive. Erosion and wetness are slight hazards. Some slopes of 2 to 3 percent erode when intensively row cropped. In seasons of high rainfall, there may be a slight drainage problem in nearly level areas. This soil seldom needs artificial drainage, but a few areas have been tile drained. Good tilth is easy to maintain under a high level of management. The response to a complete fertilizer is good.

Capability class I; management group 1.

Marshan series

The soils of the Marshan series are poorly drained, level to nearly level, black soils that are underlain by sand and gravel. They are on outwash terraces and along minor streams. Swamp grasses and sedges were the native vegetation. Most areas that are not artificially drained are now in permanent pasture. A representative profile of Marshan silty clay loam, moderately deep over sand and gravel, is described as follows.

Surface soil—
0 to 12 inches, black, moderately slowly permeable silty clay loam.
Subsoil—
12 to 25 inches, very dark grayish-brown to olive, moderately slowly permeable silty clay loam; very dark gray mottles.
Parent material—
25 to 28 inches, grayish-brown, moderately permeable, heavy loam; strong-brown mottles.
Substratum—
28 to 40 inches, yellowish-brown and brown, very rapidly permeable, stratified, fine, medium, and coarse gravel containing shale and sand.

The Marshan soils are generally medium in available nitrogen and potassium and low in available phosphorus.

Marshan silty clay loam, moderately deep over sand and gravel (Mm).—This soil has a sandy substratum and may be slightly droughty in periods of below normal rainfall. Nevertheless, it is more apt to be too wet than too dry. It is moderately productive and, if tile drained, is suitable for frequent row cropping. Tile may be difficult to install because of cave-ins.

Under a high level of management, good tilth is easy to maintain. The response to complete fertilizer is good. Lime is seldom needed.

Capability subclass IIw; management group 3.

Marshan silty clay loam, deep over sand and gravel (Md).—The sandy or gravely substratum of this soil is below a depth of 36 inches. If this soil is drained, it is suitable for frequent row cropping and is highly productive.

Capability subclass IIw; management group 3.

Muck and Mucky peat

Muck and Mucky peat are black, nearly level, very poorly drained, organic soils. They occupy large and small areas in old lakebeds and are generally surrounded or rimmed with Harpster soils. Without artificial drainage, these soils are ponded. Some areas are ponded even if they have artificial drainage, either because the tile outlets are too small or because they are submerged during periods of heavy rainfall. There are open ditches in most of the larger areas. The native vegetation was swamp grasses and sedges. The following profile of Muck, shallow, is representative of Muck and Mucky peat.

Surface soil—
0 to 11 inches, black, moderately permeable, loose peaty muck.
Subsurface soil—
11 to 17 inches, black to very dark gray, moderately permeable, loose muck.
Substratum—
17 to 30 inches, black to very dark gray, moderately permeable mucky silt loam.
30 to 35 inches, light olive-gray to olive-gray, moderately permeable silt loam.

Some areas of Muck and Mucky peat are very acid. The reaction is variable. These soils are generally high in available nitrogen and generally low in available phophorus and potassium. They may be deficient in trace elements for some crops.

Muck, shallow (Mw).—The profile of this soil is like the representative profile. The muck is 10 to 25 inches thick. If drainage is provided, this soil is suitable for continuous row cropping and is moderately to highly productive. Drained areas are used mainly for corn and soybeans. Small grains usually lodge and produce very low yields of light and chaffy grain. If only the surface is drained, the soil produces bluegrass and reed canarygrass for permanent pasture. Undrained areas are suitable only as wildlife habitats.

For high yields, this soil should be drained by tile, open intakes leading to tile, or open ditches. If enough fertilizer is applied, crop yields are usually higher in years of limited rainfall than in years of normal or excessive rainfall. Some areas need as much as 10 tons of lime per acre. Minor elements may be needed for some crops.

Capability subclass IIIw; management group 8.

Muck, moderately shallow (Mu).—The muck in this soil is 25 to 60 inches thick. If this soil is drained, it is moderately to highly productive of continuous row crops. Partially drained areas are used for pasture. Undrained areas are suitable only as wildlife habitats.

Capability subclass IIIw; management group 8.

Mucky peat, moderately shallow (My).—The organic layer of this soil contains more raw, fibrous material than the corresponding layer in Muck, shallow. This layer of mucky peat is 25 to 40 inches thick. If this soil is drained, it is suitable for continuous row crops. Potential yields are moderate to high if the drainage is effective. Tile lines should be placed in or on the mineral soil, below the mucky peat, where they are more apt to stay in alinement.

Partially drained areas are used for pasture. The undrained areas are suitable only as wildlife habitats.

Capability subclass IIIw; management group 8.

Mucky peat, deep (Mx).—The organic layer of this soil contains more raw, fibrous material than the corresponding layer of Muck, shallow. The layer of mucky peat is 40 to 60 inches thick. This soil can be used and managed in the same way as Mucky peat, moderately shallow.

Capability subclass IIIw; management group 8.

Mucky peat, shallow (Mz).—This soil is like Muck, shallow, but the organic layer contains more raw, fibrous, peaty material. The mucky peat is 10 to 25 inches thick. If this soil is drained, it is suitable for continuous row crops. Potential yields are high if the drainage is adequate. Partially drained areas are used for pasture. Undrained areas are suitable only as wildlife habitats.

Capability subclass IIIw; management group 8.

Nicollet series

The Nicollet series consists of imperfectly drained, dark-colored, upland soils that developed from glacial till. The slopes are concave and convex and range from ½ to 3 percent. The areas are large. A few spots of sand and gravel may occur. The native vegetation consisted of prairie grasses. Figure 4, p. 9, shows how Nicollet soils occur in relation to some of the other soils in the county. The following profile of Nicollet loam, on a slope of 2 percent, is representative of the series.

Surface soil—
0 to 14 inches, black, moderately permeable loam.
Subsoil—
14 to 31 inches, very dark grayish-brown and dark grayish-brown, moderately permeable clay loam.
Parent material—
31 inches+, dark grayish-brown and very dark grayish-brown, moderately permeable loam; dark-brown mottles; calcareous below a depth of 40 inches.

The Nicollet soils are generally medium to low in available nitrogen, low in phosphorus, and medium in potassium. They have a high water-holding capacity.

Nicollet loam (Nc).—This soil is suitable for frequent row cropping and is among the most productive soils in the county. Ordinarily, there is no erosion problem, but there is a slight erosion hazard on slopes of 3 percent. Slopes of 2 to 3 percent may erode if intensively row cropped. In periods of high rainfall, the nearly level areas are sometimes slightly too wet for crops, but tile is seldom used. Only a few areas are tile drained.

Under a high level of management, good tilth is easy to maintain. This soil responds well to applications of complete fertilizer. It is in row crops most of the time.

Capability class I; management group 1.

Okoboji series

The Okoboji series consists of nearly level, dark-colored soils that are very poorly drained. These soils developed from waterworked glacial till or local alluvium. They are in large and small depressions or potholes and are generally surrounded, or rimmed, with Harpster soils. Unless artificially drained, these soils are ponded. The native vegetation was swamp grasses and sedges. The following profile of Okoboji silt loam is representative of the series.

Surface soil—
0 to 10 inches, very dark gray, moderately permeable silt loam.
Subsoil—
10 to 30 inches, black, moderately slowly permeable, light silty clay loam.
Parent material—
30 inches+, gray to olive, moderately permeable, calcareous silt loam; light olive-brown mottles.

The Okoboji soils have a very high water-holding capacity. They are generally medium in available nitrogen and potassium and low in available phosphorus.

Okoboji silt loam (Ok).—This soil is highly productive and suitable for frequent row cropping if well drained artificially. Tile drains work well if suitable outlets at adequate depth can be obtained. However, tile drainage alone will not prevent flooding after heavy rains. Open intakes to tile or shallow surface ditches are needed to remove the surface water and to prevent drowning of crops. Surface ditches are probably better. Lime is seldom needed. The response to complete fertilizer is good.

Partially drained areas are used for pasture. Undrained areas are suitable only as wildlife habitats.

Capability subclass IIIw; management group 7.

Okoboji series, imperfectly drained variant

This imperfectly drained Okoboji variant occurs in the uplands in depressions that appear to be sinkholes. These depressions occur only in general soil area 3, where the limestone bedrock is nearer the surface than in the other general soil areas. The depressions have been filled with very dark colored soil material washed from the surrounding areas. In periods of high rainfall, they are temporarily flooded. The native vegetation consisted of prairie grasses. A representative profile of Okoboji silt loam, imperfectly drained variant, follows.

Surface soil—
0 to 30 inches, very dark gray to black, moderately permeable silt loam.
Subsoil—
30 to 50 inches, dark grayish-brown to grayish-brown, moderately permeable silt loam to light clay loam.

This soil is normally medium in available nitrogen and potassium and low in available phosphorus. It has a high water-holding capacity.

Okoboji silt loam, imperfectly drained variant (Op).—This soil is slightly wet in some years because of flooding or poor drainage, and crops may be damaged. Some kind of surface drainage may be needed to remove excess water. If this soil is well drained artificially, it is highly productive. It is suitable for frequent row cropping, but, because it occurs in small areas, it is usually cropped along with the surrounding soils. Under a high level of management, good tilth is easy to maintain. The response to complete fertilizer is good.

Capability subclass IIw; management group 3.

Orio series

The Orio series consists of poorly drained, nearly level, dark soils that developed in waterworked glacial material. They occur in potholes or depressions. The areas are both large and small. The native vegetation was swamp grasses and sedges. The following profile of Orio fine sandy loam is representative of the Orio soils in Humboldt County.

Surface soil—
0 to 8 inches, very dark gray, moderately permeable fine sandy loam.
Subsurface soil—
8 to 20 inches, very dark gray to dark gray, moderately permeable sandy loam to light loam.
Subsoil—
20 to 45 inches, very dark gray to gray, slowly permeable sandy clay loam; light-gray and dark-brown mottles.
Parent material—
45 to 60 inches, dark-gray, moderately permeable sandy loam.

The Orio soils have a medium water-holding capacity. They are generally medium to low in available nitrogen and low in available phosphorus and potassium.

Orio fine sandy loam (Or).—Unless this soil is artificially drained, it ponds. Tile drains work only fairly well, because of the slow permeability of the soil. Nevertheless, this soil is generally tiled along with the surrounding soils. Surface water should be removed by open intakes to tile or by shallow surface drains.

After artificial drainage has been installed, this soil is suitable for frequent row cropping. The surrounding soils are row cropped intensively, and this soil is generally cropped along with them, but it is only moderately productive at best. If this soil is well drained, it responds well to applications of complete fertilizer.

Capability subclass IIIw; management group 7.

Plattville series

The Plattville series consists of imperfectly drained, nearly level, dark-colored soils that are underlain by limestone bedrock at depths of 36 to 60 inches. These soils developed in loamy alluvium or outwash, in minor upland drainageways or along streams. They are subject to overflow or are slightly wet in periods of high rainfall. The native vegetation consisted of prairie grasses. The following profile of Plattville loam is representative of the series.

Surface soil—
 0 to 15 inches, black to very dark gray, moderately permeable loam.
Subsoil—
 15 to 48 inches, dark grayish-brown to brown, moderately permeable clay loam to loam with brown mottles.
Substratum—
 48 inches+, from 2 to 4 inches of brownish-yellow, decomposed limestone and limestone fragments over limestone bedrock.

The Plattville soils have a moderately high water-holding capacity. They are generally low in available nitrogen and phosphorus and medium in potassium.

Plattville loam (Pv).—This soil is suitable for frequent row cropping and is highly productive. Although it is slightly wet in some seasons, tile drainage is seldom needed. The response to a complete fertilizer is good.

Capability class I; management group 1.

Rolfe series

The Rolfe series consists of poorly drained, nearly level, dark-colored soils that developed from waterworked glacial till or local alluvium. They occur in depressions or potholes on the uplands. Unlike the Glencoe soils, they are not rimmed by Harpster soils. The native vegetation was swamp grasses and sedges. The following profile of Rolfe loam is representative of the series.

Surface soil—
 0 to 9 inches, very dark gray to black, moderately permeable loam.
Subsurface soil—
 9 to 16 inches, dark-gray to gray, moderately permeable silt loam.
Subsoil—
 16 to 48 inches, olive-gray, slowly to very slowly permeable clay to silty clay loam; yellowish-red mottles; black root channels and crayfish holes.
Parent material—
 48 to 62 inches, olive-gray, moderately permeable loam; light olive-brown and reddish-brown mottles; very dark gray root channels and crayfish holes.

The Rolfe soils have a high water-holding capacity. The very slowly permeable subsoil restricts the movement of air and water. Unless these soils are artificially drained, they pond. They are low in available nitrogen and phosphorus and medium in available potassium. They are medium acid to slightly acid.

Rolfe loam (Ro).—This soil is suitable for frequent row cropping if good drainage is provided. The small areas are generally cropped along with the surrounding soils. Average yields are only moderate. Winterkilling of legumes is common. This soil responds well to applications of complete fertilizer.

It is difficult to drain this soil satisfactorily. Tile drains do not remove water completely, because the subsoil is clayey and slowly to very slowly permeable. Tile lines should be placed closer together than in the Webster soils. Shallow surface ditches or open intakes to tile are needed to remove excess surface water as rapidly as possible.

Very small areas of this soil are shown on the soil map by conventional symbols.

Capability subclass IIIw; management group 7.

Sogn series

The Sogn series consists of well-drained, dark soils that occur on the Des Moines River terrace just west of the town of Humboldt. The slopes are convex and undulating. Because these soils are shallow to bedrock, they are droughty. Where they are cultivated, they are slightly erodible. The native vegetation consisted of prairie grasses. The following profile of Sogn loam, on a slope of 3 percent, is representative of the series.

Surface soil—
 0 to 10 inches, black, moderately permeable loam; limestone fragments in the lower part.
Substratum—
 10 inches+, limestone bedrock.

The depth to bedrock ranges from 10 to 15 inches in the Sogn soils, and the water-holding capacity is low. These soils are generally low in available nitrogen, phosphorus, and potassium.

Sogn loam, 2 to 5 percent slopes (SgB).—This soil is very low in productivity. It is not suitable for cultivated crops, because it is shallow to bedrock and is droughty. It is best for permanent hay or pasture. Only the nutrients that are required for grass need be added.

Capability subclass IVs; management group 13.

Storden series

The Storden series consists of excessively drained to well drained upland soils that developed from glacial till. These soils generally occur near the streams and are rolling to steep. They are moderately dark colored to light colored, depending on the slope and the degree of erosion. They are all subject to erosion. Pockets of sand and gravel are common.

These soils tend to be slightly droughty in years of below normal rainfall. The principal native vegetation was prairie grasses. Figure 4, p. 9, shows how the Storden soils occur on the landscape. Areas of Storden soils too small to permit separation into types and phases are shown on the map by conventional symbols. The following profile of Storden loam, on a slope of 11 percent, is representative of the series.

Surface soil—
 0 to 6 inches, very dark grayish-brown, moderately permeable, calcareous loam.
Parent material—
 6 to 10 inches, very dark grayish-brown and dark-brown, moderately permeable, calcareous loam.
 10 inches+, yellowish-brown, moderately permeable, calcareous loam.

The Storden soils have medium water-holding capacity. They are high in lime throughout. They are generally very low in available nitrogen and phosphorus and medium in available potassium.

Storden loam, 9 to 15 percent slopes, moderately eroded (StD2).—This soil is rolling. It has a severe erosion hazard, and cultivation should be on the contour. It is suitable for limited use for cultivated crops if contoured or terraced, but average yields will be only moderate. Rather heavy applications of fertilizers will be needed to insure the best yields. Phosphate fertilizer is particularly needed for alfalfa. This soil does not need lime.

Capability subclass IIIe; management group 12.

Storden loam, 15 to 20 percent slopes, moderately eroded (StE2).—This soil is hilly and has a severe erosion hazard. It is best used for permanent hay or pasture.

Capability subclass IVe; management group 14.

Storden loam, 20 to 30 percent slopes, severely eroded (StF3).—In some areas of this soil, less than 3 inches of the former surface layer remains. The slopes are steep and unsuitable for cultivation. Permanent pasture is the best use for this soil.

Capability subclass VIe; management group 16.

Storden loam, 30 to 50 percent slopes, severely eroded (StG3).—The surface layer of this soil is less than 3 inches thick. The slopes are very steep and unsuitable for cultivation. Ordinary farm machinery cannot be used on them, so pastures are hard to renovate. Nevertheless, permanent pasture is the best use for this soil.

Capability subclass VIIe; management group 18.

Terril series

The Terril series consists of moderately well drained, nearly level to gently rolling soils that developed from local alluvium. These soils occur at the base of sharp slopes, below Storden and Clarion soils. Because of their position, Terril soils tend to accumulate soil material rather than lose it through erosion. The surface layer is normally dark colored, but, in places where material has been deposited recently, it is light colored. There is some gullying. The native vegetation consisted of prairie grasses. The following describes a profile of Terril loam, on a slope of 1 percent.

Surface soil—
0 to 24 inches, very dark gray, moderately permeable loam.

Subsoil—
24 to 40 inches, very dark grayish-brown, moderately permeable loam.

Parent material—
40 to 50 inches, dark grayish-brown to grayish-brown, moderately permeable loam.

The Terril soils have a high water-holding capacity. They are generally medium in available nitrogen and potassium and low in available phosphorus.

Terril loam, 0 to 2 percent slopes (TeA).—This soil is suitable for frequent row cropping and is one of the most productive soils in the county. It is nearly level but is seldom too wet for crops. Under a high level of management, good tilth is easy to maintain. The response to complete fertilizer is good. Lime is seldom needed. The subsoil is favorable for plant growth. In some areas diversions may be needed to carry runoff from the higher lying slopes.

Capability class I; management group 1.

Terril loam, 2 to 5 percent slopes (TeB).—This soil is undulating. It has a slight erosion hazard, and diversions may be needed to control runoff from bordering slopes. It is seldom, if ever, too wet for crops. It is suitable for frequent row cropping and is among the most productive soils in the county.

Capability subclass IIe; management group 6.

Terril loam, 5 to 9 percent slopes (TeC).—This soil is gently rolling. It has a moderate erosion hazard, and diversions may be needed to control runoff from bordering slopes. This soil should be contoured when planted to row crops. It is suitable for frequent row cropping and is highly productive.

Capability subclass IIIe; management group 11.

Truman series

The Truman series consists of well-drained soils that developed from silty, water-deposited material. These soils occur on outwash terraces along streams. They are nearly level to hilly. All except the nearly level soil are subject to erosion. The stronger the slope, the greater the erosion hazard. The native vegetation consisted of prairie grasses. The following profile of Truman silt loam, on a slope of 3 percent, is representative of the series.

Surface soil—
0 to 10 inches, very dark gray, moderately permeable silt loam.

Subsoil—
10 to 46 inches, very dark brown to yellowish-brown, moderately permeable silt loam; yellowish-brown and dark brown mottles.

Parent material—
46 to 84 inches, grayish-brown, olive-brown, and gray, moderately permeable, calcareous silt loan; reddish-brown mottles.

Substratum—
84 to 100 inches, very rapidly permeable coarse sand and gravel.

The Truman soils are generally low in available nitrogen and phosphorus and medium in available potassium. They are slightly acid and often need lime. They have a high water-holding capacity.

Truman silt loam, 0 to 2 percent slopes (TrA).—The profile of this soil is like the representative profile, but the surface layer is 14 to 17 inches thick. This soil has no erosion hazard and has good natural drainage. It is among the most productive soils in the county and is suitable for frequent row cropping. The response to complete fertilizer is good.

Capability class I; management group 1.

Truman silt loam, 2 to 5 percent slopes (TrB).—This soil is undulating and has a slight erosion hazard. It is used mainly for cultivated crops. It is suitable for frequent row cropping and is among the most productive soils in the county.

Capability subclass IIe; management group 6.

Truman silt loam, 5 to 9 percent slopes, moderately eroded (TrC2).—This gently rolling soil has a surface layer only 3 to 6 inches thick. The erosion hazard is moderate. This soil should be contoured or terraced when used for row crops. It is suitable for cultivated crops and is highly productive if erosion is controlled.

Capability subclass IIIe; management group 11.

Truman silt loam, 9 to 15 percent slopes, moderately eroded (TrD2).—This is a rolling soil with a surface layer only 3 to 6 inches thick. The erosion hazard is severe. This soil should be contoured or terraced when it is cultivated. If erosion is controlled, it is suitable for cultivated crops and is moderately productive.

Capability subclass IIIe; management group 12.

Truman silt loam, 15 to 20 percent slopes, moderately eroded (TrE2).—This soil has a surface layer that is only

3 to 6 inches thick. It is hilly and has a severe erosion hazard; therefore, it is best suited to semipermanent hay or pasture. Row crops should not be grown more often than 1 year in 6.

Capability subclass IVe; management group 14.

Wabash series

The Wabash series consists of poorly drained, black soils that are frequently flooded. These soils are on level to slightly depressed first bottoms adjacent to streams. The level of their water table is often the same as the level of the stream water. Swamp grasses and sedges were the native vegetation. The following profile of Wabash silty clay is representative of the series.

Surface soil—
0 to 32 inches, black, slowly permeable silty clay.
Subsoil—
32 to 40 inches, black to very dark gray, very slowly permeable silty clay; dark-brown mottles.
Parent material—
40 to 50 inches, very dark gray, very slowly permeable silty clay; dark mottles.

The Wabash soils have a moderately high available water holding capacity. They are generally medium in available nitrogen and potassium and low in available phosphorus.

Wabash silty clay (Wa).—This soil is frequently flooded by the streams. It is often too wet to give good yields, and fieldwork is often delayed. Artificial drainage by tile is normally not feasible. The subsoil is very slowly permeable, and the water table in the soil is often at the same level as the stream water. When there is no difference in water levels, tile outlets do not drain. If tile drains are used, they should be placed closer together than in the Webster soils.

The surface layer of this soil is clayey and difficult to work. When plowed or cultivated it often becomes cloddy. The subsoil is high in clay, which restricts the movement of air and water. If drainage can be improved, preferably by shallow surface ditches, this soil is suitable for cultivated crops, but yields are moderate. Areas that can be cultivated generally are planted to row crops. Areas not suitable for cultivation are used for permanent pasture. This soil responds well to applications of complete fertilizer. It seldom needs lime.

Capability subclass IIIw; management group 7.

Wabash silty clay, channeled (Wb).—This soil is like Wabash silty clay, but it contains numerous oxbows and other alternate stream channels not crossable with farm machinery. The channels are often filled with water. This soil is frequently flooded and is not suitable for cultivation. It is best for permanent pasture.

Capability subclass Vw; management group 15.

Wacousta series

The Wacousta series consists of very poorly drained, black soils in potholes. The parent material is silty or loamy waterworked till or local alluvium. These soils occur in large depressions that were lakebed areas. They are generally surrounded, or rimmed, with Harpster soils. Unless they have been artificially drained, they pond after heavy rains. Swamp grasses and sedges were the native vegetation. The following profile of Wacousta silt loam is representative of the series.

Surface soil—
0 to 8 inches, black, moderately permeable silt loam.
Subsoil—
8 to 20 inches, dark olive-gray to dark-gray, moderately slowly permeable, calcareous silty clay loam; yellowish-brown mottles.
Parent material—
20 inches+, light olive-gray and olive-gray, moderately permeable, calcareous, light silty clay loam to silt loam; yellowish-brown mottles.

The Wacousta soils are generally medium in available nitrogen and potassium and low in available phosphorus. They have a high water-holding capacity.

Wacousta silt loam (Wc).—The profile of this soil is like that described as representative of the series. Some areas are included that have a mucky or peaty surface layer. This soil is suitable for frequent row cropping, but crop losses may be serious after heavy rains unless surface drainage is provided. If the soil were well drained artificially, it probably would produce high yields.

The subsoil is permeable enough to allow the use of tile, which work well where suitable outlets are available. Surface water can be removed by open intakes leading to tile lines or, preferably, by shallow surface ditches. Under a high level of management, good tilth is easy to maintain. The response to complete fertilizer is good. Lime is seldom needed.

Capability subclass IIIw; management group 7.

Waukegan series

The soils of the Waukegan series are underlain by sand or gravel. Some are droughty. The degree of droughtiness depends on the depth to sand and gravel. These soils occur on nearly level to rolling stream terraces or glacial outwash areas. The native vegetation consisted of prairie grasses. A representative profile of Waukegan loam, moderately deep over sand and gravel, on a slope of 3 percent, is described as follows.

Surface soil—
0 to 10 inches, very dark brown, moderately permeable loam.
Subsoil—
10 to 29 inches, dark-brown, moderately permeable loam.
Substratum—
29 to 50 inches, dark yellowish-brown and dark-brown sand or gravel; very rapidly permeable.

The Waukegan soils are usually low in available nitrogen and phosphorus and medium in available potassium. They are medium acid to strongly acid.

Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes (WmA).—The profile of this soil is like the representative profile. The sandy and gravelly substratum is at depths of 24 to 30 inches and is several feet thick. This soil has somewhat excessive drainage and is droughty even in years of normal rainfall. The degree of droughtiness depends on the depth to sand or gravel. The soil is suitable for cultivated crops, but yields are only moderate.

Capability subclass IIs; management group 5.

Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes (WmB).—This soil is like

Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes. It is gently undulating, and there is a slight erosion hazard. It is droughty, even in years of normal rainfall. The soil is suitable for cultivated crops, but average yields are only moderate.

Capability subclass IIs; management group 5.

Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded (WmC2).—This soil is like Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes. The surface layer, however, is only 3 to 6 inches thick. This soil is gently rolling and is subject to erosion if cultivated. Row crops should be planted on the contour to reduce runoff. Any soil lost by erosion reduces the water-holding capacity and lowers crop yields. This soil is suitable for cultivated crops, but it should be contoured or terraced. Average yields are low because of droughtiness.

Capability subclass IIIs; management group 10.

Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded (WmD2).—This soil is like Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes, except that the surface layer is only 3 to 6 inches thick. The slopes are rolling and subject to severe erosion. The best use for this soil is permanent hay or pasture.

Capability subclass IVs; management group 13.

Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes (WdA).—The surface layer of this soil is slightly thicker than that in the representative profile. The sand-and-gravel substratum is below a depth of 36 inches. This soil is well drained. It occurs in fairly large areas, is suitable for frequent row cropping, and is moderately to highly productive. A few areas may be slightly droughty in seasons of average rainfall, but most areas have adequate moisture-holding capacity. Erosion is not a problem.

Capability class I; management group 1.

Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes (WdB).—The profile of this soil is like the representative profile, but the sandy, gravelly substratum is below a depth of 36 inches. This soil is well drained. It is undulating and has a slight erosion hazard. It is suitable for frequent row cropping and is moderately to highly productive. A few areas may be slightly droughty in seasons of normal rainfall, but most areas have adequate moisture-holding capacity.

Capability subclass IIe; management group 6.

Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded (WdC2).—This gently rolling soil is well drained and seldom droughty. The sandy and gravelly substratum is below a depth of 36 inches. The surface layer has been eroded and is only 3 to 6 inches thick. Row crops should be planted on the contour to help reduce erosion. This soil is suitable for cultivated crops and is moderately productive.

Capability subclass IIIe; management group 11.

Webster series

The Webster series consists of nearly level, poorly drained, black soils of the uplands. The soils have developed from glacial till or from waterworked glacial material overlying glacial till. The native vegetation was swamp grasses. Figure 4, p. 9, shows how the Webster soils occur on the landscape. The following profile of Webster silty clay loam is representative of the series.

Surface soil—
- 0 to 18 inches, black, moderately slowly permeable silty clay loam.

Subsoil—
- 18 to 35 inches, dark-gray, moderately slowly permeable silty clay loam.

Parent material—
- 35 to 50 inches, dark-gray to grayish-brown, moderately slowly to rapidly permeable loam with lenses of silt, coherent sand, or sandy loam.
- 50 to 60 inches, grayish-brown, moderately permeable light clay loam; light brownish-gray and dark-brown mottles; may contain sandy layers.

The Webster soils have a high water-holding capacity. They are generally medium in available nitrogen and potassium and low in available phosphorus.

Webster silty clay loam (Wy).—This soil is among the most extensive in the county. It is nearly level and needs tile drainage if yields are to be high. It is used intensively for grain and is highly productive. Few areas need lime.

If tile are used for drainage, a depth of 4 feet and spacings of 90 to 100 feet, or a depth of 3½ feet and spacings of 80 to 90 feet are suggested.

Capability subclass IIw; management group 3.

Webster series, calcareous variant

Webster silty clay loam, calcareous variant (Wz).—This soil is like the soil in the representative profile, except that it is high in lime. In lime content, it is between Harpster loam and Webster silty clay loam. Because of excess lime, it is somewhat lower in available potassium than the Webster silty clay loams. It is nearly level and is used intensively for grain. It is highly productive if tiled and properly managed.

Capability subclass IIw; management group 3.

Soil Management and Productivity

This section of the report is designed to help the farmers of Humboldt County select soil management practices that will maintain or increase the productivity of their soils. It consists of descriptions of soil characteristics that affect management, a discussion of general management practices, estimates of average acre yields, and management suggestions for groups of soils that have substantially the same requirements. The major characteristics of the individual soils are summarized in table 3.

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TABLE 3.—*Major characteristics*

Map symbol	Soil	Position on landscape	Parent material	Native vegetation
Ad	Alluvial land	Bottom land	Alluvium	Willow brush and young trees.
Am	Ames loam	Upland	Glacial till	Trees
AnB	Ankeny sandy loam, 2 to 5 percent slopes	Foot slopes	Sandy colluvium	Grass
AnC	Ankeny sandy loam, 5 to 9 percent slopes	Foot slopes	Sandy colluvium	Grass
CaB	Clarion loam, 2 to 5 percent slopes	Upland	Glacial till	Grass
CaB2	Clarion loam, 2 to 5 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaC	Clarion loam, 5 to 9 percent slopes	Upland	Glacial till	Grass
CaC2	Clarion loam, 5 to 9 percent slopes, moderately eroded.	Upland	Glacial till	Grass
CaD2	Clarion loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaE2	Clarion loam, 15 to 20 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaF2	Clarion loam, 20 to 30 percent slopes, moderately eroded	Upland	Glacial till	Grass
CaG	Clarion loam, 30 to 50 percent slopes	Upland	Glacial till	Grass
CnB	Clarion loam, thin solum, 2 to 5 percent slopes	Upland	Glacial till	Grass
CnC2	Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded.	Upland	Glacial till	Grass
Co	Colo silt loam	Bottom land	Alluvium	Swamp grass and sedges.
Cp	Colo silt loam, channeled	Bottom land	Alluvium	Swamp grass and sedges.
Cr	Colo silty clay loam	Bottom land	Alluvium	Swamp grass and sedges.
Cs	Colo silty clay loam, channeled	Bottom land	Alluvium	Swamp grass and sedges.
CtB	Colo-Terril complex, 1 to 5 percent slopes	Foot slopes and bottom land.	Alluvium	Grass
CtC	Colo-Terril complex, 5 to 9 percent slopes	Foot slopes and bottom land.	Alluvium	Grass
Cv	Copas loam	Terraces and upland drainageways.	Alluvium or outwash over limestone.	Grass
Cu	Cullo silty clay loam	Upland depressions	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
DkA	Dickinson fine sandy loam, 0 to 2 percent slopes	Upland	Eolian sand or sandy glacial drift.	Grass
DkB	Dickinson fine sandy loam, 2 to 5 percent slopes	Upland	Eolian sand or sandy glacial drift.	Grass
DkC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded.	Upland	Eolian sand or sandy glacial drift.	Grass
DkD2	Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded.	Upland	Eolian sand or sandy glacial drift.	Grass
DkE3	Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded.	Upland	Eolian sand or sandy glacial drift.	Grass
DtA	Dickinson sandy loam, bench position, 0 to 2 percent slopes.	Terraces	Sandy alluvium	Grass
DtB	Dickinson sandy loam, bench position, 2 to 5 percent slopes.	Terraces	Sandy alluvium	Grass
DtC2	Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded.	Terraces	Sandy alluvium	Grass
DtD2	Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded.	Terraces	Sandy alluvium	Grass
Du	Dundas silty clay loam	Upland	Glacial till	Grass and trees
FaB	Farrar fine sandy loam, 2 to 5 percent slopes	Upland	Eolian sand over glacial till.	Grass
FaC2	Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded.	Upland	Eolian sand over glacial till.	Grass
FaD2	Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded.	Upland	Eolian sand over glacial till.	Grass
Ga	Garmore silt loam	Upland	Glacial till	Grass
Gc	Glencoe silty clay loam	Upland depressions	Local alluvium or waterworked glacial till.	Swamp grass and sedges.
Ha	Harpster loam	Upland	Glacial till	Grass
Hb	Harpster loam, sand and gravel substratum	Upland or terraces	Outwash or alluvium	Grass
Hc	Harpster silt loam	Terraces	Alluvium	Grass

See footnotes at end of table.

of the mapping units

Organic-matter content	Surface soil		Subsoil texture [2]	Permeability classes	Natural drainage
	Relative color [1]	Texture [2]			
Variable	Variable	Variable	Variable	Variable	Variable.
Medium	Moderately dark	Medium	Moderately fine to fine	Very slow	Poor.
Medium	Dark	Moderately coarse	Moderately coarse	Rapid	Somewhat excessive.
Medium	Dark	Moderately coarse	Moderately coarse	Rapid	Somewhat excessive.
High	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
High	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
High	Dark	Medium	Moderately fine	Moderately slow	Poor.
High	Dark	Medium	Moderately fine	Moderately slow	Poor.
High	Very dark	Moderately fine	Moderately fine	Moderately slow	Poor.
High	Very dark	Moderately fine	Moderately fine	Moderately slow	Poor.
High	Dark	Medium and moderately fine.	Moderately fine to medium.	Moderate to moderately slow.	Good to poor.
High	Dark	Medium and moderately fine.	Moderately fine to medium.	Moderate to moderately slow.	Good to poor.
Medium	Dark	Medium	Medium	Moderate	Good.
High	Dark	Moderately fine	Moderately fine	Slow	Poor.
Low	Dark	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Dark	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Moderately light	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Dark	Moderately coarse	Moderately coarse	Rapid	Excessive.
Low	Dark	Moderately coarse	Moderately coarse	Rapid	Excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Rapid	Excessive.
Low	Light	Moderately coarse	Moderately coarse	Rapid	Excessive.
High	Dark	Moderately fine	Fine	Slow to very slow	Poor.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Somewhat excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Somewhat excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Somewhat excessive.
High	Dark	Medium	Moderately fine	Moderate	Moderately good.
High	Very dark	Moderately fine	Moderately fine	Slow to very slow	Very poor.
High	Dark	Medium	Moderately fine to medium.	Moderate to moderately slow.	Poor.
High	Dark	Medium	Moderately fine to medium.	Moderate to moderately slow.	Poor.
High	Dark	Medium	Medium	Moderate	Poor.

TABLE 3.—*Major characteristics*

Map symbol	Soil	Position on landscape	Parent material	Native vegetation
HdB	Hayden loam, 2 to 5 percent slopes	Upland	Glacial till	Trees
HdC2	Hayden loam, 5 to 9 percent slopes, moderately eroded	Upland	Glacial till	Trees
HdD2	Hayden loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Trees
HdE2	Hayden loam, 15 to 20 percent slopes, moderately eroded.	Upland	Glacial till	Trees
HsF	Hayden soils, 20 to 50 percent slopes	Upland	Glacial till	Trees
Hu	Huntsville silt loam	Bottom land	Alluvium	Grass
Hv	Huntsville silt loam, channeled	Bottom land	Alluvium	Grass and trees
KmA	Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
KmB	Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
KdA	Kato loam, deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
KdB	Kato loam, deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
LaC2	Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded.	Upland	Gravelly stratified glacial drift.	Grass
LaE2	Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded.	Upland	Gravelly stratified glacial drift.	Grass
LfB	Lamont fine sandy loam, 2 to 5 percent slopes	Upland	Eolian material over glacial till.	Trees
LfC2	Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded.	Upland	Eolian material over glacial till.	Trees
LfD2	Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded.	Upland	Eolian material over glacial till.	Trees
LfE2	Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded.	Upland	Eolian material over glacial till.	Trees
LmB	Lester loam, 2 to 5 percent slopes	Upland	Glacial till	Grass and trees
LmC2	Lester loam, 5 to 9 percent slopes, moderately eroded	Upland	Glacial till	Grass and trees
LmD2	Lester loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Grass and trees
LmE2	Lester loam, 15 to 20 percent slopes, moderately eroded	Upland	Glacial till	Grass and trees
LsF	Lester soils, 20 to 30 percent slopes	Upland	Glacial till	Grass and trees
LsG	Lester soils, 30 to 50 percent slopes	Upland	Glacial till	Grass and trees
Lu	LeSueur loam	Upland	Glacial till	Grass and trees
Md	Marshan silty clay loam, deep over sand and gravel	Terraces	Glacial outwash	Swamp grass and sedges.
Mm	Marshan silty clay loam, moderately deep over sand and gravel.	Terraces	Glacial outwash	Swamp grass and sedges.
Mu	Muck, moderately shallow	Upland	Organic matter	Swamp grass and sedges.
Mw	Muck, shallow	Upland	Organic matter	Swamp grass and sedges.
Mx	Mucky peat, deep	Upland	Organic matter	Swamp grass and sedges.
My	Mucky peat, moderately shallow	Upland	Organic matter	Swamp grass and sedges.
Mz	Mucky peat, shallow	Upland	Organic matter	Swamp grass and sedges.
Nc	Nicollet loam	Upland	Glacial till	Grass
Ok	Okoboji silt loam	Upland	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
Op	Okoboji silt loam, imperfectly drained variant	Upland	Local alluvium	Grass
Or	Orio fine sandy loam	Upland	Glacial drift	Swamp grass and sedges.
Pv	Plattville loam	Upland and terraces	Alluvium or outwash over limestone.	Grass
Ro	Rolfe loam	Upland	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
SgB	Sogn loam, 2 to 5 percent slopes	Terraces	Glacial drift over limestone.	Grass
StD2	Storden loam, 9 to 15 percent slopes, moderately eroded	Upland	Glacial till	Grass
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded.	Upland	Glacial till	Grass
StF3	Storden loam, 20 to 30 percent slopes, severely eroded	Upland	Glacial till	Grass
StG3	Storden loam, 30 to 50 percent slopes, severely eroded	Upland	Glacial till	Grass

See footnotes at end of table.

of the mapping units—Continued

Organic-matter content	Surface soil		Subsoil texture [2]	Permeability classes	Natural drainage
	Relative color [1]	Texture [2]			
Medium	Moderately dark	Medium	Moderately fine	Moderately slow	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderately slow	Good.
Medium	Light	Medium	Moderately fine	Moderately slow	Good.
Low	Light	Medium	Moderately fine	Moderately slow	Good.
Low	Light	Medium	Moderately fine	Moderately slow	Good.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
Low	Moderately dark	Moderately coarse	Coarse	Rapid	Excessive.
Low	Moderately dark	Moderately coarse	Coarse	Rapid	Excessive.
Low	Moderately dark	Moderately coasre	Moderately coarse	Moderately rapid	Excessive.
Low	Moderately dark	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Light	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Low	Light	Moderately coarse	Moderately coarse	Moderately rapid	Excessive.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Low	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
Medium	Dark	Medium	Moderately fine	Moderate to moderately slow.	Imperfect.
High	Very dark	Moderately fine	Moderately fine	Moderately slow	Poor.
High	Very dark	Moderately fine	Moderately fine	Moderately slow	Poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Very dark	(3)	Medium	Moderate	Very poor.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Moderately fine	Moderately slow	Very poor.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
Medium	Dark	Moderately coarse	Moderately fine	Slow	Poor.
High	Dark	Medium	Moderately fine	Moderate	Imperfect.
High	Dark	Medium	Fine	Very slow	Poor.
Medium	Dark	Medium	Limestone bedrock	Moderate	Good.
Low	Moderately dark	Medium	Medium	Moderate	Excessive to good.
Low	Light	Medium	Medium	Moderate	Excessive to good.
Low	Light	Medium	Medium	Moderate	Excessive to good.
Low	Light	Medium	Medium	Moderate	Excessive to good.

TABLE 3.—*Major characteristics*

Map symbol	Soil	Position on landscape	Parent material	Native vegetation
TeA	Terril loam, 0 to 2 percent slopes	Foot slopes	Local alluvium	Grass
TeB	Terril loam, 2 to 5 percent slopes	Foot slopes	Local alluvium	Grass
TeC	Terril loam, 5 to 9 percent slopes	Foot slopes	Local alluvium	Grass
TrA	Truman silt loam, 0 to 2 percent slopes	Terraces	Alluvium	Grass
TrB	Truman silt loam, 2 to 5 percent slopes	Terraces	Alluvium	Grass
TrC2	Truman silt loam, 5 to 9 percent slopes, moderately eroded.	Terraces	Alluvium	Grass
TrD2	Truman silt loam, 9 to 15 percent slopes, moderately eroded.	Terraces	Alluvium	Grass
TrE2	Truman silt loam, 15 to 20 percent slopes, moderately eroded.	Terraces	Alluvium	Grass
Wa	Wabash silty clay	Bottom land	Alluvium	Swamp grass and sedges.
Wb	Wabash silty clay, channeled	Bottom land	Alluvium	Swamp grass and sedges.
Wc	Wacousta silt loam	Upland depressions	Waterworked glacial till or local alluvium.	Swamp grass and sedges.
WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
WmB	Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
WmC2	Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	Terraces	Glacial outwash	Grass
WmD2	Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded.	Terraces	Glacial outwash	Grass
WdA	Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes.	Terraces	Glacial outwash	Grass
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes.	Terraces	Glacial outwash	Grass
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	Terraces	Glacial outwash	Grass
Wy	Webster silty clay loam	Upland	Waterworked glacial till or glacial till.	Swamp grasses
Wz	Webster silty clay loam, calcareous variant	Upland	Waterworked glacial till or glacial till.	Swamp grasses

[1] Based on generalized observations of soil colors in cultivated fields. Color differences are evident in moist soils but become more pronounced when the soil is dry. The terms refer to color differences within Humboldt County, not to differences throughout the country. For more exact color values, refer to the soil descriptions.

Soil Management

Know the characteristics of your soils before you adopt a plan for controlling erosion and improving or maintaining their productivity. The following are among the more important characteristics to be considered.

Drainage and permeability.—These are related characteristics of soils. Drainage is the movement of water through soils, and permeability is the quality of the soil that enables it to transmit water and air. Thus, by studying the texture, porosity, cracking, and other characteristics of layers in the soil, one may appraise its permeability.

Many very slowly permeable soils have unsatisfactory drainage for plant growth. Very rapidly permeable soils, unless they have a high water table, are excessively drained and are usually too droughty for good plant growth in normal seasons.

Permeability affects runoff during rains and, therefore, the rate of erosion. Slowly permeable soils absorb water more slowly and have more runoff than rapidly permeable soils.

More information about drainage and permeability will be found in the section, Soil Survey Methods and Definitions. You may refer also to the section, Soil Series and Mapping Units, where the characteristics of individual soils are described.

Texture.—The texture of a soil affects the amount of water it will hold; the permeability, or the rate at which water moves through the soil; and the ease with which the soil can be cultivated and penetrated by plant roots. Texture is considered in determining the need for irrigation and the system to be used, the kind of drainage system to install, and the choice of crops.

Slope.—The slope of the soil is important in determining the need for erosion control. The steeper the slope, the faster the rate of runoff and erosion. Slopes of more than 2 percent are normally subject to erosion when they are cultivated. Erosion losses are greater in places where there is no plant cover. Steep slopes limit the use of *of the mapping units*—Continued

Organic-matter content	Surface soil		Subsoil	Permeability classes	Natural drainage
	Relative color [1]	Texture [2]	texture [2]		
High	Dark	Medium	Medium	Moderate	Moderately good.
High	Dark	Medium	Medium	Moderate	Moderately good.
High	Dark	Medium	Medium	Moderate	Moderately good.
High	Dark	Medium	Medium	Moderate	Good.
High	Dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Medium	Moderately dark	Medium	Medium	Moderate	Good.
Low	Moderately dark	Medium	Medium	Moderate	Good.
High	Very dark	Fine	Fine	Very slow	Poor.
High	Very dark	Fine	Fine	Very slow	Poor.
High	Dark	Medium	Moderately fine	Moderately slow	Very poor.
Medium	Dark	Medium	Medium	Moderate	Somewhat excessive.
Medium	Dark	Medium	Medium	Moderate	Somewhat excessive.
Low	Moderately dark	Medium	Medium	Moderate	Somewhat excessive.
Low	Moderately dark	Medium	Medium	Moderate	Somewhat excessive.
High	Dark	Medium	Moderately fine	Moderate	Good.
High	Dark	Medium	Moderately fine	Moderate	Good.
Medium	Moderately dark	Medium	Moderately fine	Moderate	Good.
High	Very dark	Moderately fine	Moderately fine	Moderate to moderately slow.	Poor.
High	Very dark	Moderately fine	Moderately fine	Moderate to moderately slow.	Poor.

[2] General terms for texture are defined as follows: Coarse—sand and loamy sand; moderately coarse—sandy loam and fine sandy loam; medium—very fine sandy loam, loam, silt loam, and silt; moderately fine—clay loam, sandy clay loam, and silty clay loam; fine—sandy clay, silty clay, and clay.

[3] Mucky peat; no texture description.

farm machinery, and stands of row crops are generally thinner than on mild slopes.

Organic-matter content.—The content of organic matter is normally related to the color of the soil. Ordinarily, the darker the color, the higher the organic-matter content. Sandy soils generally contain less organic matter than less sandy soils of the same color. A high organic-matter content, in turn, indicates a high total nitrogen level, but the nitrogen may not be readily available to plants. Light-colored soils generally need more nitrogen fertilizer than dark-colored soils.

General management practices

Efficient management of soils is planned with the characteristics of the soils in mind. Selection of a combination of practices suited to the soils is essential. In the following paragraphs, the major management practices are discussed in general terms. More specific suggestions on management will be found in the subsection, Management groups.

Artificial drainage.—Wet soils do not produce high yields of corn, soybeans, alfalfa, or small grains. Corn and alfalfa, for example, must be able to root deeply if they are to grow well. Plants develop shallow roots in wet soils; nutrients are not readily available; planting and cultivation are often delayed; and weeds are difficult to control.

Poorly drained soils need tile lines or open ditches to carry away the excess water (fig. 7). If outlets for the lines are available, tile drains work well in soils that are moderately or moderately slowly permeable. Open ditches, or surface drains, should be used if the soils are very slowly permeable, because tile drains will not carry off the water adequately.

Erosion control.—Unless measures are taken to control erosion, gullies may form and crops may be buried in silt. Drainage ditches, road ditches, and ponds may be filled. Erosion increases the cost of production and reduces crop yields. The soil material lost through erosion

Figure 7.—**Drainage ditch, Norway Township, typical of the ditches used as tile outlets to improve soil drainage.**

contains the largest amounts of organic matter and plant nutrients.

Erosion by water can be controlled by contouring, terracing, and stripcropping; by planting meadow crops; and by installing diversion ditches. Wind erosion can be reduced by leaving oat stubble, cornstalks, or other plant remains on the surface or partly buried. This practice, called mulch tillage, is generally advisable on sandy soils.

Soil Conservation Service representatives or the County Extension Director can help plan practices that will control erosion.

Liming and fertilizing.—The need for lime and fertilizers varies with the kind of soil, the past management, the crops grown, and the fertility level of the soil. The need is best determined by testing samples of soils. Only general suggestions for fertilizing are given in this report because of the continuing development of new fertilizers and because of the different and changing needs of each field.

The soil map, which shows the boundaries of the soils, is the best guide for sampling. The maximum size of a soil area that should be represented by one sample is about 10 acres. The County Extension Director will furnish further information about soil testing and about fertilization based on soil tests.

The need for lime is indicated by records on soil testing in Humboldt County. Of 1,575 soil samples tested for lime, 41 percent were calcareous and 28 percent were slightly acid. This indicates that 69 percent of the soils need no applications of lime. The testing further indicated that 12 percent of the soils need 1½ to 2 tons of lime per acre; 13 percent of the soils need 2½ to 3 tons; 5 percent need 3½ to 4 tons, and 1 percent of the soils need more than 4 tons. The results of testing soil samples for nitrogen, phosphorus, and potassium are shown in table 4.

Crop rotation.—A suitable crop rotation is part of good soil management. No one rotation is best suited to all farms or soils. A rotation suitable for a farmer with adequate capital and a broad livestock program is not suitable for a farmer having little livestock or capital. Sloping soils that erode readily need rotations different from those used on level soils that do not erode.

Suggested crop rotations or land use, with accompanying erosion control practices, are given in the subsection, Management groups, and in table 5. Use of suitable rotations and appropriate soil conserving practices will insure maximum long-time productivity, reduce erosion losses to a reasonable minimum, and help to maintain a satisfactory level of organic matter. Fertilization according to needs shown by soil tests is essential if a rotation is to have its maximum beneficial effect.

In choosing a crop rotation for a farm or field, consider the character of the soils, their potential productivity, and the erosion control required. The fertility of the soils, the need for livestock feed and pasture, and the economic situation must also be considered.

Soil Productivity

Before choosing a cropping system for a soil, some estimate of the soils productivity is needed. Table 5 is provided to aid you in this. It lists acre yields of the principal crops grown in the county. The estimates are based on a high level of management that includes the following:

1. Controlling erosion.
2. Planting corn at rates that will produce—
   a. 14,000 to 16,000 plants per acre for soils having estimated yields of more than 65 bushels per acre.
   b. 12,000 to 14,000 plants per acre for soils having estimated yields of 50 to 65 bushels per acre.
   c. 10,000 to 12,000 plants per acre for soils having estimated yields of less than 50 bushels per acre.
3. Applying fertilizer and lime in the kinds and amounts indicated by soil tests, so as to reach a level of fertilization approaching that suggested by the testing laboratory of Iowa State University.
4. Using cropping systems suggested in the subsection, Management groups, and in table 5.
5. Draining wet soils by tile or surface drains and determining that the drainage provided is working effectively.
6. Using suitable varieties of crops.
7. Controlling weeds, diseases, and insects in the manner now used by good farmers.
8. Doing farm work at the proper time.
9. Controlling floods.

In making the estimates it was further assumed that the practices listed had been followed for at least 10 years.

TABLE 4.—*Content of nitrogen, phosphorus, and potassium in 1,575 soil samples*

Soil samples	Samples rated according to content of—												
	Nitrogen [1]				Phosphorus [2]				Potassium [2]				
	Very low	Low	Medium	High	Very low	Low	Medium	High	Very low	Low	Low to medium	Medium	High
Noncalcareous________percent__	6	62	27	4	16	60	18	6	0	6	43	39	12
Calcareous___________percent__	1	52	36	11	49	41	8	2	3	10	38	37	12

[1] For all samples tested during 1953 and 1954. [2] For all samples tested prior to July 1, 1954.

The average yields in table 5 are thought to be fairly reliable appraisals of what can be expected from the soils of the county. They are based on research data from experimental farms, on the experience of farmers, and on the judgment of soil scientists and the agronomy staff at Iowa State University. Year-to-year fluctuations in yields are normal and are to be expected. A few farmers, using the best techniques and management known today, can be expected to obtain yields 10 to 15 percent higher than the estimated yields. Of course, introduction of new crop varieties, of better fertilization practices, or of other improved methods may make necessary a revision of the averages in the future.

Planning the Farm

After you have identified the different soils, noted the general practices of good soil management, and studied the special needs of your soils, you may want to work out a more efficient program of land use and soil management. You can obtain assistance in planning and applying practices from the Soil Conservation Service and the County Extension Director.

Some fields, especially those in rolling areas, contain two or more soils that call for widely different rotations and other management. If one of the soils occupies a very small acreage, it may have to be farmed the same as the rest of the field. On some farms one rotation is suitable for the entire farm, but the special practices, such as contouring, draining, or fertilizing, are different for each soil area. On such a farm, soil areas are commonly large enough to permit using two or more sets of rotations at the same time, or to allow rearrangement of field boundaries so as to keep together the soils that need similar management.

Ordinarily, several good field arrangements and cropping systems can be worked out for any given farm. More than one cropping system may be needed on some farms. For example, on a farm with undulating and rolling land and some bottom land, two different rotations may be needed if the farm is to be cropped to best advantage.

In drawing up your farm plan, consider carefully the characteristics of the soils; rotation of crops; erosion control and drainage; need for fertilizer and lime; expected crop yields; and capability of the soils as defined in the capability classification used by the Soil Conservation Service.

If drainage is a problem, perhaps that is the place to start. If alfalfa and brome meadows are to be established, the lime requirements should be checked in advance. Field rearrangements may be accomplished more conveniently when an area is in meadow. Terraces can be conveniently constructed on meadow that will be plowed for corn. If contouring is to be established on land in first-year corn, do not plow out all of the meadow before planting the corn. Leave strips of sod on the headlands and in places where machinery will be turned to help keep these areas safe from erosion.

Capability Groups of Soils

Capability grouping is a system of classification used to show the relative suitability of soils for crops, grazing, forestry, or wildlife. It is a practical grouping based on the needs and limitations of the soils, the risks of damage to them, and their response to management. In this report, soils have been placed in three consecutively broader categories, management groups, subclasses, and classes.

The management group, which can also be called a capability unit, is the lowest level of capability grouping. A management group is made up of soils that need about the same kind of management and are similar in risk of damage and in general suitability for use.

The next broader grouping, the subclass, is used to indicate the dominant kind of limitation. The letter symbol "e" means that the main limiting factor is risk of erosion if the plant cover is not maintained. The symbol "w" means that excess water retards plant growth or interferes with cultivation. The symbol "s" means that the soils are shallow, droughty, or low in fertility.

The broadest grouping, the class, is identified by Roman numerals. All the soils in one class have limitations and management problems of about the same degree, but of different kinds, as shown by the subclass. Except for class I, each class has one or more subclasses.

In classes I, II, and III are soils that are suitable for annual or periodic cultivation for annual or short-lived crops.

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TABLE 5.—*Suggested rotations, principal*

[Absence of yield figure indicates that the soil is not

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
Ad	Alluvial land	15(Vw)	Flooding
Am	Ames loam	7(IIIw)	Ponding and wetness
AnB	Ankeny sandy loam, 2 to 5 percent slopes	5(IIs)	Droughtiness
AnC	Ankeny sandy loam, 5 to 9 percent slopes	10(III)s	Droughtiness; moderate erosion hazard
CaB	Clarion loam, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard
CaB2	Clarion loam, 2 to 5 percent slopes, moderately eroded	6(IIe)	Slight erosion hazard
CaC	Clarion loam, 5 to 9 percent slopes	11(IIIe)	Moderate erosion hazard
CaC2	Clarion loam, 5 to 9 percent slopes, moderately eroded	11(IIIe)	Moderate erosion hazard
CaD2	Clarion loam, 9 to 15 percent slopes, moderately eroded.	12(IIIe)	Severe erosion hazard
CaE2	Clarion loam, 15 to 20 percent slopes, moderately eroded.	14(IVe)	Severe erosion hazard
CaF2	Clarion loam, 20 to 30 percent slopes, moderately eroded.	16(VIe)	Severe erosion hazard
CaG	Clarion loam, 30 to 50 percent slopes	18(VIIe)	Severe erosion hazard
CnB	Clarion loam, thin solum, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard
CnC2	Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded.	11(IIIe)	Moderate erosion hazard
Co	Colo silt loam	2(IIw)	Some flooding; wetness
Cp	Colo silt loam, channeled	15(Vw)	Severe flooding; wetness
Cr	Colo silty clay loam	2(IIw)	Some flooding; wetness
Cs	Colo silty clay loam, channeled	15(Vw)	Severe flooding; wetness
CtB	Colo-Terril complex, 1 to 5 percent slopes	3(IIw)	Wetness; gullying
CtC	Colo-Terril complex, 5 to 9 percent slopes	11(IIIe)	Wetness; erosion hazard
Cv	Copas loam	5(IIs)	Droughtiness
Cu	Cullo silty clay loam	7(IIIw)	Ponding; wetness
DkA	Dickinson fine sandy loam, 0 to 2 percent slopes	9(IIIs)	Droughtiness
DkB	Dickinson fine sandy loam, 2 to 5 percent slopes	9(IIIs)	Droughtiness; slight erosion hazard
DkC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded.	13(IVs)	Droughtiness; moderate erosion hazard
DkD2	Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded.	17(VIs)	Droughtiness; severe erosion hazard
DkE3	Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded.	17(VIs)	Droughtiness; severe erosion hazard
DtA	Dickinson sandy loam, bench position, 0 to 2 percent slopes.	9(IIIs)	Droughtiness
DtB	Dickinson sandy loam, bench position, 2 to 5 percent slopes.	9(IIIs)	Droughtiness; slight erosion hazard
DtC2	Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded.	13(IVs)	Droughtiness; slight erosion hazard
DtD2	Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded.	17(VIs)	Droughtiness; severe erosion hazard
Du	Dundas silty clay loam	3(IIw)	Wetness
FaB	Farrar fine sandy loam, 2 to 5 percent slopes	5(IIs)	Droughtiness; slight erosion hazard
FaC2	Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded.	10(IIIs)	Droughtiness; moderate erosion hazard
FaD2	Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded.	13(IVs)	Droughtiness; severe erosion hazard

See footnotes at end of table.

management practices, and expected yields

suitable for the crop, or the crop is not commonly grown]

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay [3]
		Bushels	*Bushels*	*Bushels*	*Tons*
Permanent pasture or woodland	None	------	------	------	------
Same as surrounding soils	Tile and surface drainage if soil is cultivated	45	17	35	1.8
Corn, oats, and meadow	None	42	15	35	2.0
Corn for 2 years, oats, and meadow	Contouring	42	15	35	2.0
Corn, oats, and meadow for 2 years	Contouring	40	------	30	1.8
Corn for 2 years, oats, and meadow	Terracing	40	------	30	1.8
Corn for 2 years, oats, and meadow for 2 years	None	72	28	52	3.0
Corn for 3 years, oats, and meadow	Contouring	72	28	52	3.0
Corn for 2 years, oats, and meadow for 2 years	None	69	26	49	3.0
Corn for 3 years, oats, and meadow	Contouring	69	26	49	3.0
Corn, oats, and meadow for 4 years	None	68	------	49	2.9
Corn, oats, and meadow for 2 years	Contouring	68	------	49	2.9
Corn for 3 years, oats, and meadow	Terracing	68	------	49	2.9
Corn, oats, and meadow for 4 years	None	65	------	47	2.8
Corn, oats, and meadow for 2 years	Contouring	65	------	47	2.8
Corn for 2 years, oats, and meadow	Terracing	65	------	47	2.8
Corn, oats, and meadow for 3 years	Contouring	57	------	40	2.6
Corn for 2 years, oats, and meadow for 2 years	Terracing	57	------	40	2.6
Permanent hay	None	45	------	39	2.2
Corn, oats, and meadow for 4 years	Stripcropping	45	------	39	2.2
Permanent pasture	None	------	------	------	------
Permanent pasture	None	------	------	------	------
Corn for 2 years, oats, and meadow for 2 years	None	67	24	48	2.5
Corn for 3 years, oats, and meadow	Contouring	67	24	48	2.5
Corn, oats, and meadow for 2 years	Contouring	58	------	43	2.4
Corn for 2 years, oats, and meadow	Terracing	58	------	43	2.4
Corn for 3 years, and oats, followed by a legume for green manure.	Protection from overflow; drainage	60	24	40	------
Permanent pasture or woodland	None	------	------	------	------
Corn for 3 years and oats, followed by a legume for green manure.	Protection from overflow; drainage	62	25	50	------
Permanent pasture or woodland	None	------	------	------	------
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	66	26	50	------
Corn, oats, and meadow for 2 years	Contouring	65	------	50	2.8
Corn for 2 years, oats, and meadow	Terracing	65	------	50	2.8
Corn for 2 years, oats, and meadow	None	40	17	34	1.6
Corn for 3 years, oats, and meadow	Tile and surface drainage	65	27	50	2.0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile and surface drainage	59	25	45	------
Corn, oats, and meadow	None	40	16	37	2.0
Corn, oats, and meadow	None	38	15	37	2.0
Corn, oats, and meadow for 2 years	Stripcropping	32	------	30	1.6
Corn, oats, and meadow	Terracing	32	------	30	1.6
Permanent pasture	None	------	------	------	------
Permanent pasture	None	------	------	------	------
Corn, oats, and meadow	None	38	15	30	1.3
Corn, oats, and meadow	None	35	14	28	1.2
Corn, oats, and meadow for 2 years	Stripcropping	28	------	25	1.0
Corn, oats, and meadow	Terracing	28	------	25	1.0
Permanent pasture	None	------	------	------	------
Corn for 3 years, oats, and meadow	Tile drainage	66	25	45	2.8
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	60	22	40	------
Corn, oats, and meadow	None	50	16	36	2.0
Corn for 2 years, oats, and meadow	Contouring	50	16	36	2.0
Corn, oats, and meadow for 2 years	Contouring	44	------	28	1.8
Corn for 2 years, oats, and meadow	Terracing	44	------	28	1.8
Hay or pasture	None	------	------	------	1.5
Corn, oats, and meadow for 2 years	Stripcropping	34	------	26	1.5
Corn, oats, meadow	Terracing	34	------	26	1.5

TABLE 5.—*Suggested rotations, principal management*

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
Ga	Garmore silt loam	1(I)	None
Gc	Glencoe silty clay loam	7(IIIw)	Ponding; wetness
Ha	Harpster loam	4(IIw)	Wetness; low fertility
Hb	Harpster loam, sand and gravel substratum	4(IIw)	Wetness; low fertility
Hc	Harpster silt loam	4(IIw)	Wetness; low fertility
HdB	Hayden loam, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard; low fertility
HdC2	Hayden loam, 5 to 9 percent slopes, moderately eroded	11(IIIe)	Moderate erosion hazard; low fertility
HdD2	Hayden loam, 9 to 15 percent slopes, moderately eroded	12(IIIe)	Severe erosion hazard; low fertility
HdE2	Hayden loam, 15 to 20 percent slopes, moderately eroded.	14(IVe)	Severe erosion hazard; low fertility
HsF	Hayden soils, 20 to 50 percent slopes	18(VIIe)	Severe erosion hazard; low fertility
Hu	Huntsville silt loam	2(IIw)	Slight wetness; some flooding
Hv	Huntsville silt loam, channeled	15(Vw)	Severe flooding; wetness
KmA	Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	5(IIs)	Slight droughtiness or slight wetness
KmB	Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	5(IIs)	Slight droughtiness; slight erosion hazard
KdA	Kato loam, deep over sand and gravel, 0 to 2 percent slopes.	1(I)	Slight wetness in some years
KdB	Kato loam, deep over sand and gravel, 2 to 5 percent slopes.	6(IIe)	Slight erosion hazard; slight wetness in some years.
LaC2	Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded.	13(IVs)	Severe droughtiness; moderate erosion hazard
LaE2	Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded.	17(VIs)	Extreme droughtiness; severe erosion hazard
LfB	Lamont fine sandy loam, 2 to 5 percent slopes	5(IIs)	Droughtiness; slight erosion hazard
LfC2	Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded.	10(IIIs)	Droughtiness; moderate erosion hazard
LfD2	Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded.	13(IVs)	Droughtiness; severe erosion hazard
LfE2	Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded.	17(VIs)	Droughtiness; severe erosion hazard
LmB	Lester loam, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard
LmC2	Lester loam, 5 to 9 percent slopes, moderately eroded	11(IIIe)	Moderate erosion hazard
LmD2	Lester loam, 9 to 15 percent slopes, moderately eroded	12(IIIe)	Severe erosion hazard
LmE2	Lester loam, 15 to 20 percent slopes, moderately eroded	14(IVe)	Severe erosion hazard
LsF	Lester soils, 20 to 30 percent slopes	16(VIe)	Severe erosion hazard
LsG	Lester soils, 30 to 50 percent slopes	18(VIIe)	Severe erosion hazard
Lu	LeSueur loam	1(I)	Slight wetness in some years
Md	Marshan silty clay loam, deep over sand and gravel	3(IIw)	Wetness
Mm	Marshan silty clay loam, moderately deep over sand and gravel.	3(IIw)	Wetness

See footnotes at end of table.

practices, and expected yields—Continued

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay [3]
		Bushels	*Bushels*	*Bushels*	*Tons*
Corn for 3 years, oats, and meadow	None	75	29	55	3. 4
Corn for 3 years, and oats, followed by a legume for green manure.	None	68	27	50	--------
Same as surrounding soils	Tile and surface drainage	(4)	(4)	(4)	(4)
Same as surrounding soils	Applying phosphate and potash fertilizers; tile drainage.	57	22	40	2. 5
Same as surrounding soils	Applying phosphate and potash fertilizers; tile drainage.	55	21	40	2. 5
Corn for 3 years, oats, and meadow	Applying phosphate and potash fertilizers; tile drainage.	63	25	42	2. 6
Corn for 3 years, and oats, followed by a legume for green manure.	Applying phosphate and potash fertilizers; tile drainage.	58	23	38	--------
Corn for 2 years, oats, and meadow for 2 years	None	62	22	43	2. 8
Corn for 3 years, oats, and meadow	Contouring	62	22	43	2. 8
Corn, oats, and meadow for 2 years	Contouring	55	--------	40	2. 6
Corn for 2 years, oats, and meadow	Terracing	55	--------	40	2. 6
Corn, oats, and meadow for 3 years	Contouring	48	--------	36	2. 4
Corn for 2 years, oats, and meadow for 2 years	Terracing	48	--------	36	2. 4
Permanent hay	None	--------	--------	--------	2. 0
Corn, oats, and meadow for 4 years	Stripcropping	37	--------	32	2. 0
Permanent pasture or woodland	None	--------	--------	--------	--------
Corn for 3 years, and oats, followed by a legume for green manure.	Protection from overflow; drainage	62	25	48	--------
Permanent pasture or woodland	None	--------	--------	--------	--------
Corn for 2 years, oats, and meadow	None	52	21	40	2. 0
Corn, oats, and meadow	None	50	19	38	2. 0
Corn for 2 years, oats, and meadow	Contouring	50	19	38	2. 0
Corn for 3 years, oats, and meadow	Tile drainage if needed	73	29	53	3. 0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage if needed	66	26	48	--------
Corn for 2 years, oats, and meadow for 2 years	Tile drainage if needed	68	27	50	2. 9
Corn for 3 years, oats, and meadow	Tile drainage if needed; contouring	68	27	50	2. 9
Corn, oats, and meadow for 2 years	Stripcropping	22	--------	18	. 7
Permanent pasture	None	--------	--------	--------	--------
Corn, oats, and meadow	None	35	16	32	1. 7
Corn for 2 years, oats, and meadow	Contouring	35	16	32	1. 7
Corn, oats, and meadow for 2 years	Contouring	30	--------	27	1. 1
Corn for 2 years, oats, and meadow	Terracing	30	--------	27	1. 1
Corn, oats, and meadow for 2 years	Stripcropping	25	--------	23	1. 0
Corn, oats, and meadow	Terracing	25	--------	23	1. 0
Permanent pasture or woodland	None	--------	--------	--------	--------
Corn for 2 years, oats, and meadow for 2 years	None	69	25	49	2. 9
Corn for 3 years, oats, and meadow	Contouring	69	25	49	2. 9
Corn, oats, and meadow for 2 years	Contouring	61	--------	45	2. 8
Corn for 2 years, oats, and meadow	Terracing	61	--------	45	2. 8
Corn, oats, and meadow for 3 years	Contouring	54	--------	40	2. 6
Corn for 2 years, oats, and meadow for 2 years	Terracing	54	--------	40	2. 6
Permanent hay	None	--------	--------	--------	2. 2
Corn, oats, and meadow for 4 years	Stripcropping	42	--------	34	2. 2
Permanent pasture or woodland	None	--------	--------	--------	--------
Permanent pasture or woodland	None	--------	--------	--------	--------
Corn for 3 years, oats, and meadow	Tile drainage if needed	67	25	50	3. 0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage if needed	60	23	45	--------
Corn for 3 years, oats, and meadow	Tile drainage	73	27	55	3. 2
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	66	25	50	--------
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	57	23	50	2. 6
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	52	21	45	--------

TABLE 5.—*Suggested rotations, principal management*

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
Mu	Muck, moderately shallow	8(IIIw)	Ponding; wetness
Mw	Muck, shallow	8(IIIw)	Ponding; wetness
Mx	Mucky peat, deep	8(IIIw)	Ponding; wetness
My	Mucky peat, moderately shallow	8(IIIw)	Ponding; wetness
Mz	Mucky peat, shallow	8(IIIw)	Ponding; wetness
Nc	Nicollet loam	1(I)	Slight wetness in some years
Ok	Okoboji silt loam	7(IIIw)	Ponding; wetness
Op	Okoboji silt loam, imperfectly drained variant	3(IIw)	Wetness
Or	Orio fine sandy loam	7(IIIw)	Ponding; wetness
Pv	Plattville loam	1(I)	Slight wetness
Ro	Rolfe loam	7(IIIw)	Ponding; wetness
SgB	Sogn loam, 2 to 5 percent slopes	13(IVs)	Droughtiness; shallowness
StD2	Storden loam, 9 to 15 percent slopes, moderately eroded	12(IIIe)	Severe erosion hazard; low fertility
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded	14(IVe)	Severe erosion hazard; low fertility
StF3	Storden loam, 20 to 30 percent slopes, severely eroded	16(VIe)	Severe erosion hazard; low fertility
StG3	Storden loam, 30 to 50 percent slopes, severely eroded	18(VIIe)	Severe erosion hazard; low fertility
TeA	Terril loam, 0 to 2 percent slopes	1(I)	Runoff from bordering slopes
TeB	Terril loam, 2 to 5 percent slopes	6(IIe)	Runoff from bordering slopes
TeC	Terril loam, 5 to 9 percent slopes	11(IIIe)	Moderate erosion hazard
TrA	Truman silt loam, 0 to 2 percent slopes	1(I)	None
TrB	Truman silt loam, 2 to 5 percent slopes	6(IIe)	Slight erosion hazard
TrC2	Truman silt loam, 5 to 9 percent slopes, moderately eroded.	11(IIIe)	Moderate erosion hazard
TrD2	Truman silt loam, 9 to 15 percent slopes, moderately eroded.	12(IIIe)	Severe erosion hazard
TrE2	Truman silt loam, 15 to 20 percent slopes, moderately eroded.	14(IVe)	Severe erosion hazard
Wa	Wabash silty clay	7(IIIw)	Flooding; wetness
Wb	Wabash silty clay, channeled	15(Vw)	Severe flooding; wetness
Wc	Wacousta silt loam	7(IIIw)	Ponding; wetness
WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes.	5(IIs)	Droughtiness
WmB	Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes.	5(IIs)	Droughtiness
WmC2	Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	10(IIIs)	Droughtiness; moderate erosion hazard
WmD2	Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded.	13(IVs)	Droughtiness; severe erosion hazard
WdA	Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes.	1(I)	None

See footnotes at end of table.

practices, and expected yields—Continued

Suggested land use and principal accompanying management practices: Rotations [1] and other land use	Suggested land use and principal accompanying management practices: Management	Expected average crop yields per acre under a high level of management [2]: Corn	Soybeans	Oats	Hay
		Bushels	*Bushels*	*Bushels*	*Tons*
Continuous row crops	Tile and surface drainage	(4)	(4)	--------	--------
Pasture	Partial drainage	--------	--------	--------	--------
Continuous row crops	Tile and surface drainage	(4)	(4)	--------	--------
Pasture	Partial drainage	--------	--------	--------	--------
Continuous row crops	Tile and surface drainage	(4)	(4)	--------	--------
Pasture	Partial drainage	--------	--------	--------	--------
Continuous row crops	Tile and surface drainage	(4)	(4)	--------	--------
Pasture	Partial drainage	--------	--------	--------	--------
Continuous row crops	Tile and surface drainage	(4)	(4)	--------	--------
Pasture	Partial drainage	--------	--------	--------	--------
Corn for 3 years, oats, and meadow	Tile drainage, if needed	78	30	55	3.4
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage, if needed	70	28	50	--------
Corn for 3 years, and oats, followed by a legume for green manure.	Tile and surface drainage	(4)	(4)	(4)	(4)
Same as surrounding soils	Drainage	[4] 65	25	40	2.5
Same as surrounding soils	Tile and surface drainage, if soil is cultivated	[4] 46	20	40	2.1
Corn for 3 years, oats, and meadow	Tile or surface drainage, if needed	68	28	50	3.0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile or surface drainage, if needed	60	25	45	--------
Same as surrounding soils	Tile and surface drainage, if soil is cultivated	(4)	(4)	(4)	(4)
Corn, oats, and meadow for 2 years	None	15	--------	15	.7
Pasture	None	--------	--------	--------	--------
Corn, oats, and meadow for 3 years	Contouring	45	--------	35	2.0
Corn for 2 years, oats, and meadow for 2 years	Terracing	45	--------	35	2.0
Pasture or hay	None	--------	--------	--------	2.0
Permanent hay	None	--------	--------	--------	1.6
Corn, oats, meadow for 4 years	Stripcropping	35	--------	31	1.6
Permanent pasture	None	--------	--------	--------	--------
Permanent pasture	None	--------	--------	--------	--------
Corn for 3 years, oats, and meadow	None	75	28	55	3.4
Corn for 3 years, and oats, followed by a legume for green manure.	None	68	26	50	--------
Corn for 2 years, oats, and meadow for 2 years	Diversions, if needed	73	28	55	3.4
Corn for 3 years, oats, and meadow	Diversions, if needed, and contouring	73	28	55	3.4
Corn, oats, and meadow for 2 years	Contouring	69	--------	50	3.2
Corn for 3 years, oats, and meadow	Terracing	69	--------	50	3.2
Corn for 3 years, oats, and meadow	None	78	30	55	3.4
Corn for 3 years, and oats, followed by a legume for green manure.	None	70	28	50	--------
Corn for 2 years, oats, and meadow for 2 years	None	72	28	52	3.2
Corn for 3 years, oats, and meadow	Contouring	72	28	52	3.2
Corn, oats, and meadow for 2 years	Contouring	65	--------	47	2.8
Corn for 2 years, oats, and meadow	Terracing	65	--------	47	2.8
Corn, oats, and meadow for 3 years	Contouring	57	--------	40	2.6
Corn for 2 years, oats, and meadow for 2 years	Terracing	57	--------	40	2.6
Permanent hay	None	--------	--------	--------	2.2
Corn, oats, and meadow for 4 years	Stripcropping	45	--------	39	2.2
Corn for 3 years, and oats, followed by a legume for green manure.	Surface drainage	45	22	30	--------
Permanent pasture or woodland	None	--------	--------	--------	--------
Corn for 3 years and oats, followed by a legume for green manure.	Tile and surface drainage	(4)	(4)	(4)	--------
Corn for 2 years, oats, and meadow	None	41	16	35	2.0
Corn, oats, and meadow	None	39	14	33	1.9
Corn for 2 years, oats, and meadow	Contouring	39	14	33	1.9
Corn, oats, and meadow for 2 years	Contouring	33	--------	29	1.7
Corn for 2 years, oats, and meadow	Terracing	33	--------	29	1.7
Corn, oats, and meadow for 2 years	Stripcropping	27	--------	27	1.3
Corn, oats, and meadow	Terracing	27	--------	27	1.3
Corn for 3 years, and oats, followed by a legume for green manure.	None	65	26	53	2.8
Corn for 3 years, and oats, followed by a legume for green manure.	None	58	24	48	--------

TABLE 5.—*Suggested rotations, principal management*

Map symbol	Soil	Management group and capability class and subclass	Most serious limitations
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes.	6(IIe)	Slight erosion hazard
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.	11(IIIe)	Moderate erosion hazard
Wy	Webster silty clay loam	3(IIw)	Wetness
Wz	Webster silty clay loam, calcareous variant	3(IIw)	Wetness; low fertility

[1] The most intensive use of row crops consistent with good soil conservation is set forth in the suggested rotations, which must be accompanied by the principal practices listed. Grain sorghum or soybeans may be substituted for corn; other small grains may be substituted for oats.

[2] See text for what is meant by "a high level of management" and for the basis on which yields were estimated.

[3] Hay yields based on first-year stands and three cuttings during

Class I soils are those that have the widest range of use and the least risk of damage. They are level or nearly level, productive, well drained, and easy to work. They can be cultivated with almost no risk of erosion and will remain productive if managed with normal care.

Class II soils can be cultivated regularly, but they 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. Other soils in class II may be slightly droughty, slightly wet, or somewhat limited in depth.

Class III soils can be cropped regularly, but they have a narrower range of use than class II soils, and they need even 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 normally should not be cultivated for annual or short-lived crops but can be used for pasture, for woodland, or for wildlife shelter.

Class V soils are nearly level and gently sloping, but they are droughty, wet, low in fertility, or otherwise unsuitable for cultivation.

Class VI soils are not suitable for cultivated crops, because they are steep or droughty or otherwise limited, but they give fair yields of forage and fair to high yields of forest products. Some soils in class VI can, without damage, be cultivated enough so that trees can be set out or pasture crops seeded.

Class VII soils provide only poor to fair yields of forage. Yields of forest products may be fair to high. The soils have characteristics that restrict their use mainly to pasture and, in some places, to trees.

In class VIII are soils that have practically no agricultural use. Some areas have value for watershed protection, wildlife shelter, or recreation. None of the soils in Humboldt County were placed in class VIII.

The capability classes and subclasses and management groups of Humboldt County are the following:

Class I.—Soils that have few limitations that restrict their use.
- Management group 1.—Level and nearly level soils that can be cultivated without special management practices.

Class II.—Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.
- Subclass IIw.—Wet soils that generally can be drained satisfactorily with tile.
  - Management group 2.—Poorly drained and imperfectly drained soils of the bottom lands.
  - Management group 3.—Level to nearly level, dark-colored soils that are poorly drained and imperfectly drained.
  - Management group 4.—Poorly drained, "high-lime" soils.
- Subclass IIs.—Slightly droughty soils.
  - Management group 5.—Nearly level to undulating soils that are slightly droughty.
- Subclass IIe.—Soils that have a moderate erosion hazard if they are not protected.
  - Management group 6.—Dark colored and moderately dark colored, undulating, well drained and imperfectly drained soils.

Class III.—Soils that have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Subclass IIIw.—Soils that have serious wetness problems.
  - Management group 7.—Poorly drained and very poorly drained soils.
  - Management group 8.—Organic soils.
- Subclass IIIs.—Droughty and slightly droughty soils that are subject to wind or water erosion.
  - Management group 9.—Nearly level and undulating soils that are very droughty.
  - Management group 10.—Gently rolling, slightly droughty soils.
- Subclass IIIe.—Gently rolling and rolling soils that can be cultivated safely if protected from erosion.
  - Management group 11.—Gently rolling, well-drained soils.

practices, and expected yields—Continued

Suggested land use and principal accompanying management practices		Expected average crop yields per acre under a high level of management [2]			
Rotations [1] and other land use	Management	Corn	Soybeans	Oats	Hay [3]
		Bushels	*Bushels*	*Bushels*	*Tons*
Corn for 2 years, oats, and meadow for 2 years	None	62	25	52	2.6
Corn for 3 years, oats, and meadow	Contouring	62	25	52	2.6
Corn, oats, and meadow for 2 years	Contouring	50	--------	42	2.2
Corn for 3 years, oats, and meadow	Terracing	50	--------	42	2.2
Corn for 3 years, oats, and meadow	Tile drainage	76	29	55	3.2
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	68	27	50	--------
Corn for 3 years, oats, and meadow	Tile drainage	69	24	50	3.0
Corn for 3 years, and oats, followed by a legume for green manure.	Tile drainage	61	22	45	--------

the year. If soil is suited to alfalfa, hay crop is assumed to consist of alfalfa and bromegrass.

[4] Yields for these soils are highly variable because complete drainage is seldom obtained. They are pothole soils, and they pond after heavy rains unless excellent surface drainage has been installed. The soils are potentially productive, however, except for the Orio soils, and average yields of 45 to 75 bushels can be expected if flooding is controlled.

Management group 12.—Rolling, well-drained soils.

Class IV.—Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Subclass IVs.—Droughty soils that are suitable for only limited cultivation.

Management group 13.—Soils that are low in fertility, or subject to wind or water erosion, or both.

Subclass IVe.—Hilly soils that can be cultivated safely only if appropriate conservation practices are followed.

Management group 14.—Hilly, well-drained soils that are moderately eroded and generally contain only a small amount of organic matter.

Class V.—Soils that have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to grazing, pasture, woodland, or wildlife.

Subclass Vw.—Wet soils that are not suitable for cultivation without artificial drainage and protection from overflow.

Management group 15.—Soils of the bottom lands that are subject to flooding.

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

Subclass VIe.—Soils that erode readily but, under careful management, are fairly well suited to trees or pasture.

Management group 16.—Steep, erodible soils that have thin surface layers.

Subclass VIs.—Droughty soils that, under careful management, are fairly well suited to pasture.

Management group 17.—Rolling to hilly, sandy and gravelly soils that are moderately to severely eroded.

Class VII.—Soils that have very severe limitations that make them unsuitable for cultivation and restrict their use largely to grazing, woodland, and wildlife.

Subclass VIIe.—Soils that are steep, or severely eroded, or both.

Management group 18.—Hilly and steep soils.

Management groups

A management group consists of soils that require about the same kind of management. The soils in any one group have hazards of the same degree and kind and respond in about the same way.

MANAGEMENT GROUP 1(I)

Management group 1 consists of level and nearly level soils that have few limitations that restrict their use. They can be cultivated without special practices. The soils are—

- Garmore silt loam.
- Kato loam, deep over sand and gravel, 0 to 2 percent slopes.
- LeSueur loam.
- Nicollet loam.
- Plattville loam.
- Terril loam, 0 to 2 percent slopes.
- Truman silt loam, 0 to 2 percent slopes.
- Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes.

These soils are well drained to imperfectly drained. They are permeable to a depth of several feet and have a large capacity for holding water that plants can use. They are well supplied with organic matter. Tilth is very good and is easy to maintain. All these soils are good to excellent for crops and pasture.

Use and management.—The soils in this group are well suited to frequent row cropping. Although row crops can be grown almost every year, a suitable rotation is 3 years of row crops, 1 year of a small grain, and 1 year of meadow. If the soils are heavily fertilized, an alternative rotation is 3 years of corn and a year of small grain with a legume interplanted for green manure.

Good crop yields are obtained without fertilizer, but, for maintaining high yields under intensive use, fertilizer is needed. The response to fertilizer is good because sufficient moisture is held in the soils. Plants have the moisture needed to utilize the plant nutrients applied, and high yields can be obtained. Nitrogen is needed for corn that does not follow a legume crop. The amounts of lime and fertilizer to be applied should be based on the results of soil tests.

Although these soils can be farmed without artificial drainage, some of them have a slight drainage problem in years of high rainfall. In these years, tile drains help to maintain yields.

Erosion is not ordinarily a problem. Nevertheless, under intensive row cropping, it may be best to contour the long slopes.

If corn is to be planted in spring, these soils are usually plowed the preceding fall. This subjects the soils to wind erosion. Leaving a plowed surface rough and leaving strips of vegetation unplowed help to reduce wind erosion.

MANAGEMENT GROUP 2 (IIw)

Management group 2 consists of fertile bottom-land soils that are poorly and imperfectly drained. These soils are suitable for frequent row cropping. The soils are—

Colo silt loam.
Colo silty clay loam.
Huntsville silt loam.

These level to nearly level soils are occasionally flooded, but the hazard varies from area to area. The soils hold a large quantity of water available for plants but have moderate to moderately slow permeability. They erode only along channels where banks are cut.

The soils of this group are neutral to slightly acid. They are fairly well supplied with plant nutrients and are very productive if flooding is controlled and good drainage is provided.

Use and management.—These soils are easily worked, and good tilth is easily maintained. Although they are suitable for many different crops, corn and soybeans are the chief crops grown.

If complete fertilizer is applied, row crops can be grown several years in succession without depleting the soils. In most areas, however, a suitable rotation consists of 3 years of row crops and 1 year of a small grain with a legume interplanted for green manure, or 3 years of row crops, 1 year of small grain, and 1 year of meadow.

Nitrogen is needed for corn that does not follow a legume. Phosphorus is especially needed for legume-and-grass hay and pasture. The response to potassium is good.

In most areas of these soils, drainage is needed. Tile drains function well if outlets are large enough and are not submerged in periods of high rainfall.

MANAGEMENT GROUP 3 (IIw)

The soils in management group 3 are dark colored and level to nearly level. They are poorly drained and imperfectly drained but are well suited to frequent row cropping if artificially drained. The soils are—

Colo-Terril complex, 1 to 5 percent slopes.
Dundas silty clay loam.
Marshan silty clay loam, deep over sand and gravel.
Marshan silty clay loam, moderately deep over sand and gravel.
Okoboji silt loam, imperfectly drained variant.
Webster silty clay loam.
Webster silty clay loam, calcareous variant.

These soils are wet and generally need artificial drainage. They have a fairly large to large capacity for holding water that plants can use. They have a medium to large supply of plant nutrients and organic matter. Some of these soils are slightly acid; some are slightly calcareous; the Dundas soil is medium acid to strongly acid. The soils are fairly easy to work except after a long rainy period.

Use and management.—Because of the smooth surface, high fertility, good response to fertilizer, and good water-holding capacity, these soils are well suited to intensive use if artificially drained. Tile work well. The Okoboji variant needs surface drainage in some places. Information on drainage can be obtained from the local representative of the Soil Conservation Service or the County Extension Director, or it can be found in the Iowa Drainage Guide (*6*).

If these soils have been adequately drained, they are suited to corn, soybeans, oats, legumes, grasses, and most other farm crops. A suggested rotation is 3 years of row crops, 1 year of small grain, and a year of meadow; or 3 years of row crops and 1 year of a small grain with a legume interplanted for green manure. Undrained areas not used for grain are ordinarily suitable for birdsfoot trefoil and bluegrass.

These soils are usually plowed in fall because wetness may delay work in spring. Although fall plowing subjects the soils to wind erosion in winter and early in spring, corn yields are higher than when the soils are plowed in spring. The freezing and thawing or wetting and drying produce more favorable tilth in fall-plowed soil than in spring-plowed soil, and a better seedbed can be prepared. Leaving crop residues on the surface or leaving unplowed strips across a field helps to reduce wind erosion.

All of these soils respond well to fertilizer and produce high crop yields. They are deficient in available phosphorus and potassium. Nitrogen should be applied to corn that does not follow a legume crop.

These soils are somewhat slow to warm up in spring. When they are to be planted to corn, it is best to apply a starter fertilizer. This is best done with an attachment on the planter.

In some places runoff accumulates and grassed waterways are needed. Other erosion control practices are unnecessary.

MANAGEMENT GROUP 4 (IIw)

Management group 4 consists of nearly level, poorly drained, "high-lime" soils. They are suitable for frequent row cropping if heavily fertilized. They are—

Harpster loam.
Harpster loam, sand and gravel substratum.
Harpster silt loam.

These soils occur in both large and small areas. In plowed fields that are dry on the surface, they appear distinctly grayer than the surrounding soils. They are moderately high to high in organic matter and very low in available phosphorus and potassium. The low availability of phosphorus is related to the high lime content, and the low availability of potassium is related to the high lime content and the poor drainage. These soils have a large capacity for holding water that plants can use.

Use and management.—These soils are suited to corn, soybeans, oats, legumes, grasses, and most other farm crops. A suitable rotation is 3 years of row crops and a year of small grain followed by meadow, or 3 years of row crops and a year of oats with a legume interplanted for green manure. Small areas of these soils are cropped along with the surrounding soils.

Unless the soils are heavily fertilized, corn yields are commonly 30 bushels per acre lower than on the adjacent soils. Large amounts of phosphate and potash fertilizer are needed if high yields are to be obtained under intensive cropping. Nitrogen is especially needed for corn that does not follow a good legume crop. Legumes respond well to phosphate fertilizers. The amount of fertilizer applied should be based on soil tests. No lime should be applied.

Because the soils do not contain enough iron for soybeans, the leaves commonly turn yellow when the plants are only a few inches high. The iron deficiency can be corrected by repeated foliar spraying with a ferrous sulfate solution.

These soils need drainage, and tile work well. Erosion control practices are not needed.

MANAGEMENT GROUP 5(IIs)

Management group 5 consists of nearly level to undulating soils that are slightly droughty and low in fertility. The soils in this group are—

- Ankeny sandy loam, 2 to 5 percent slopes.
- Copas loam.
- Farrar fine sandy loam, 2 to 5 percent slopes.
- Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes.
- Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes.
- Lamont fine sandy loam, 2 to 5 percent slopes.
- Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes.
- Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes.

These soils are only moderately productive. They contain a small to medium amount of organic matter. They are mostly medium acid to slightly acid. They do not hold a large amount of moisture for plants. At times the Kato soils are slightly wet.

Use and management.—These soils are suitable for corn, soybeans, oats, alfalfa, and hay and pasture. Crop yields are normally only moderate and are rather low in dry seasons. Thinner stands of corn should be planted than on less droughty soils. Suggested for these soils is a year each of a row crop, a small grain, and meadow, or, if sloping soils are contoured, 2 years of row crops, a year of small grain, and a year of meadow. This group of soils may be more profitably used for forage crops than grain crops.

Droughtiness and low fertility are the major management problems. For best yields, these soils need organic matter in the form of barnyard manure or crop residues, and lime as well as fertilizer to supply the needed plant nutrients. The amounts to be applied should be based on soil tests. Heavy applications of fertilizer are not advisable, because the soils are droughty. The response to light applications is fairly good.

On the sandier soils of this group, wind erosion is sometimes severe and blowing sand may damage young plants. Crop residues left on the surface help to reduce damage by wind erosion. These soils are easy to work. They do not need artificial drainage.

MANAGEMENT GROUP 6(IIe)

Management group 6 consists of dark colored and moderately dark colored, undulating soils that are well drained and imperfectly drained. These soils are very productive. They are—

- Clarion loam, 2 to 5 percent slopes.
- Clarion loam, 2 to 5 percent slopes, moderately eroded.
- Clarion loam, thin solum, 2 to 5 percent slopes.
- Hayden loam, 2 to 5 percent slopes.
- Kato loam, deep over sand and gravel, 2 to 5 percent slopes.
- Lester loam, 2 to 5 percent slopes.
- Terril loam, 2 to 5 percent slopes.
- Truman silt loam, 2 to 5 percent slopes.
- Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes.

The surface layers are friable. The subsoils are permeable, and the movement of air and water is usually good. These soils can hold a large amount of water available for plants. Most of them are neutral to slightly acid. Some of the soils have somewhat irregular slopes. The soils vary considerably in their content of organic matter. On the whole, they contain a moderately large amount of plant nutrients. They have good tilth.

Use and management.—Because of rather high fertility, good tilth, favorable moisture relations, and gentle slopes, these soils are well suited to corn, soybeans, and oats. They are also well suited to alfalfa, red clover, bromegrass, orchardgrass, and other hay and pasture plants. Suggested rotations are the following: With contouring, 3 years of row crops, a year of small grain, and a year of meadow; without contouring, 2 years of row crops, a year of small grain, and 2 years of meadow.

Runoff causes some erosion on the stronger slopes if they are cultivated up and down hill. Unless meadow crops are grown 2 years out of 5, cultivation should be on the contour. Contouring is difficult on some of the irregular slopes. Tile drainage is seldom needed.

Phosphate and potash fertilizers are needed on these soils for all crops. Nitrogen is ordinarily needed for corn that does not follow a good legume-grass meadow. Hayden and Lester soils are less well supplied with nitrogen than the other soils in the group. Lime needs are variable. The amounts of lime and fertilizer applied should be based on soil tests.

MANAGEMENT GROUP 7(IIIw)

Management group 7 consists of poorly drained and very poorly drained soils that are in nearly level areas and depressions. These soils are moderately productive. They are—

- Ames loam.
- Cullo silty clay loam.
- Glencoe silty clay loam.
- Okoboji silt loam.
- Orio fine sandy loam.
- Rolfe loam.
- Wabash silty clay.
- Wacousta silt loam.

Most of these soils are in potholes, or landlocked depressions, that are frequently flooded after heavy rains. Runoff is slow. Except for the Orio soil, all the soils have a large capacity for holding water available for plants. They have firm or very firm subsoils, which are moderately slowly to very slowly permeable. They are mildly alkaline to strongly acid.

Use and management.—Except for Wabash silty clay, these soils are normally too wet for cultivation unless they are artificially drained. If they are cultivated when too wet, they are apt to become puddled and cloddy. If drained, they are suited to corn, soybeans, small grains, grasses, and other commonly grown farm crops. Alfalfa and clover ordinarily do not do well, because of wetness and winterkilling. No rotations are suggested for this management group, because most areas of these soils are small and are cropped along with the surrounding soils. Undrained areas might be seeded to wetland pasture grasses.

When these soils are adequately drained, they respond well to lime and fertilizer, especially to potash and phosphate. Nitrogen normally is needed for corn that does not follow a good legume crop. The Ames and Orio soils are less well supplied with nitrogen than the other soils in the group. Lime needs are variable. The amounts of lime and fertilizer applied should be based on soil tests.

Barnyard manure and crop residues will help maintain good tilth. Erosion control is not needed.

Tile systems do not drain the soils completely. Shallow surface ditches or open intakes leading to tile may reduce ponding. In many places it is difficult to put tile outlets at a sufficient depth to provide good drainage. Information on tile drainage can be found in the Iowa Drainage Guide (*6*).

MANAGEMENT GROUP 8(IIIw)

Management group 8 consists of very poorly drained, dark-colored, organic soils. The soils in this group are—

Muck, moderately shallow.
Muck, shallow.
Mucky peat, deep.
Mucky peat, moderately shallow.
Mucky peat, shallow.

These soils are in depressions that were formerly marshes, swamps, or shallow lakes. Runoff is slow. The substrata have moderate to slow permeability. The soils have a large capacity for holding water available to plants. They are high in organic matter and in natural fertility, but the balance of plant nutrients is somewhat poor. They may be deficient in some trace elements. These soils are mildly alkaline to strongly acid. Their surface layers are friable and have good tilth.

Use and management.—These soils are not suited to cultivation until drainage is provided. If they are properly drained, they are well suited to corn and soybeans. Some truck crops can be grown. These soils are somewhat cold and slow to warm up in spring. Crops are subject to early frost in fall; therefore, early maturing varieties of corn and soybeans are preferable. Areas that are only partially drained and too wet for cultivation can be used for permanent pasture. Undrained areas are suitable as wildlife habitats.

Most of the larger areas of these soils have been drained by both tile and open ditches. Some areas, however, are ponded after heavy rains. If suitable outlets are available, tile normally work well, but open ditches or open intakes leading to tile may be needed to prevent ponding.

If high yields are to be obtained, phosphate and potash fertilizers are needed. The amount of lime needed is variable and may be as much as 10 tons an acre. Minor elements may be deficient.

MANAGEMENT GROUP 9(IIIs)

Management group 9 consists of nearly level and undulating soils that are very droughty. The soils in this group are—

Dickinson fine sandy loam, 0 to 2 percent slopes.
Dickinson fine sandy loam, 2 to 5 percent slopes.
Dickinson sandy loam, bench position, 0 to 2 percent slopes.
Dickinson sandy loam, bench position, 2 to 5 percent slopes.

These soils contain only a small amount of organic matter. They are medium acid to slightly acid. They are excessively drained and dry out quickly after rains.

Use and management.—These soils are easy to work. Although they are droughty and low in fertility, they can be used for corn, grain sorghum, oats, and winter rye. They are also suitable for alfalfa, bromegrass, orchardgrass, and other hay and pasture plants. Yields are generally low. Thinner stands of corn should be planted than on less droughty soils. A suggested rotation is a year of a row crop, a year of small grain, and a year of meadow. It may prove more profitable to grow grasses and legumes than grains.

For best yields, apply lime and fertilizer in amounts based on soil tests. Because the soils are droughty, heavy applications of fertilizer are not economical. The response to light applications is good.

Wind erosion is commonly severe, and blowing sand may damage young plants. Crop residues left on the surface help to reduce the damage. Water erosion on the stronger slopes is a serious hazard.

MANAGEMENT GROUP 10(IIIs)

Management group 10 consists of gently rolling, slightly droughty soils. The soils are medium to low in productivity. They are—

Ankeny sandy loam, 5 to 9 percent slopes.
Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded.
Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded.
Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.

These soils contain a small to medium amount of organic matter. They are mostly medium acid to slightly acid. They have a limited capacity for holding water that plants can use.

Use and management.—These soils are easy to work. If they are used for crops, droughtiness, erosion, and low fertility are the major management problems. Corn, oats, and alfalfa are suitable crops. Crop yields are not high, even in years of above average rainfall. Fewer corn plants per acre should be planted than on soils that are less droughty.

A suggested rotation for these soils, if they are not contoured, is a year of a row crop, a year of small grain, and 3 years of meadow. With contouring, a rotation consisting of a year of a row crop, a year of small grain, and 2 years of meadow is suggested. With terraces, a rotation made up of 2 years of row crops, a year of small grain, and a year of meadow can be used.

For best yields, apply organic matter in the form of barnyard manure or crop residues. Commercial fertilizer and lime are also needed. The amounts to apply should be based on soil tests. Heavy applications of fertilizer are not economical, because the soils are droughty. The response to light applications is good.

These soils are moderately susceptible to erosion. They should be contoured and terraced where feasible. Maintaining terraces is difficult if there is loose sand, but generally terraces work well on these soils. Stripcropping may be feasible on irregular slopes. Wind erosion is sometimes a serious hazard, and blowing sand may damage young plants on the sandy loam. Crop residues left on the surface help to reduce the damage.

MANAGEMENT GROUP 11 (IIIe)

Management group 11 consists mostly of well-drained soils on gently rolling, generally short and irregular slopes. They are—

- Clarion loam, 5 to 9 percent slopes.
- Clarion loam, 5 to 9 percent slopes, moderately eroded.
- Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded.
- Colo-Terril complex, 5 to 9 percent slopes.
- Hayden loam, 5 to 9 percent slopes, moderately eroded.
- Lester loam, 5 to 9 percent slopes, moderately eroded.
- Terril loam, 5 to 9 percent slopes.
- Truman silt loam, 5 to 9 percent slopes, moderately eroded.
- Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded.

These soils are moderately to highly productive. Except for Terril loam, 5 to 9 percent slopes, and Colo-Terril complex, 5 to 9 percent slopes, they are well drained. They have a large capacity for holding water that plants can use; have a small to medium supply of organic matter; and, for the most part, are slightly acid.

Use and management.—Ordinarily, these soils are easy to work. Because of good tilth, high fertility, and favorable moisture relations, they are suitable for corn and oats, and for alfalfa, bromegrass, orchardgrass, and other hay and pasture plants. Unless erosion can be controlled, however, their use for cultivated crops is limited. If the soils are not contoured, a suggested rotation is a year of a row crop, a year of small grain, and 4 years of meadow. A suggested rotation for contoured soils is a year of a row crop, a year of small grain, and 2 years of meadow. If the soils are terraced, row crops can be grown for 2 years and followed by a year of small grain and a year of meadow.

These soils erode readily if cultivated. Contouring and terracing will reduce runoff and soil loss. Irregular slopes that are not contoured or terraced ought to be used for meadow longer than areas that are contoured and terraced.

All the soils generally need phosphate and potash fertilizers for all crops. They need nitrogen fertilizer for corn that does not follow a good legume-grass meadow. Lime needs are variable. The amounts of lime and fertilizer to apply should be based on soil tests.

MANAGEMENT GROUP 12 (IIIe)

Management group 12 consists of rolling, well-drained soils on slopes that are mostly short and irregular. The soils in this group are moderately productive. They are—

- Clarion loam, 9 to 15 percent slopes, moderately eroded.
- Hayden loam, 9 to 15 percent slopes, moderately eroded.
- Lester loam, 9 to 15 percent slopes, moderately eroded.
- Storden loam, 9 to 15 percent slopes, moderately eroded.
- Truman silt loam, 9 to 15 percent slopes, moderately eroded.

These are light colored to moderately dark colored soils. Except for the Storden loam, they are medium acid. They hold a large quantity of water available for plants.

Use and management.—The soils of this group are easy to work. Their medium fertility, moderately good tilth, and favorable moisture relations make them suitable for corn and oats, as well as for alfalfa, bromegrass, orchardgrass, and other hay and pasture crops. The strong slopes limit cultivation, unless erosion can be controlled.

These soils erode readily if cultivated. They should be contoured and terraced wherever possible to reduce soil losses. Suggested rotations: Without contouring, a year of small grain and 3 years of meadow; with contouring, a year of a row crop, a year of small grain, and 3 years of meadow; with terraces, 2 years of row crops, a year of small grain, and 2 years of meadow; with stripcropping, a year of a row crop, a year of small grain, and 2 years of meadow.

Ordinarily, all crops grown on these soils need phosphate and potash fertilizers. Phosphate fertilizer is especially needed on the Storden loam. Nitrogen is generally needed for corn that does not follow an excellent legume-grass meadow. Lime needs are variable. Base the application of lime and fertilizer on soil tests. For high yields, fertilization must be moderately heavy.

MANAGEMENT GROUP 13 (IVs)

Management group 13 consists of mostly gently rolling to rolling, droughty soils that are of limited use for cultivated crops. These soils are low in productivity. They are—

- Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded.
- Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded.
- Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded.
- Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded.
- Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded.
- Sogn loam, 2 to 5 percent slopes.
- Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded.

These soils are medium acid and low in plant nutrients. They absorb moisture well, but they are droughty because they are sandy or are underlain by sand, gravel, or bedrock.

Use and management.—These soils are easy to work, though their usefulness is limited by droughtiness and low fertility. They are probably best for permanent hay or pasture. Alfalfa, bromegrass, and orchardgrass are suitable plants. Corn and oats are grown, but yields are not high. If the soils are stripcropped, a rotation suggested is a year of a row crop, a year of small grain, and 2 years of meadow. This rotation is suitable for the Sogn soil without erosion control practices. If the soils are terraced, a suitable rotation is a year of a row crop, a year of small grain, and a year of meadow.

Unless these soils are contoured and terraced, they erode readily if planted to row crops. Sometimes wind erosion is severe, and blowing sand may damage young plants on the sandy loams. Crop residues left on the surface help to reduce the damage.

These soils respond well to light applications of fertilizer. Apply lime and fertilizer according to needs shown by soil tests. Heavy fertilization is not economical, because the soils are droughty.

MANAGEMENT GROUP 14(IVe)

Management group 14 consists of well-drained, hilly soils that are moderately productive. The soils in this group are—

- Clarion loam, 15 to 20 percent slopes, moderately eroded.
- Hayden loam, 15 to 20 percent slopes, moderately eroded.
- Lester loam, 15 to 20 percent slopes, moderately eroded.
- Storden loam, 15 to 20 percent slopes, moderately eroded.
- Truman silt loam, 15 to 20 percent slopes, moderately eroded.

Most of these soils are low in organic matter and available phosphorus. They can hold a large amount of water that plants can use. Runoff is rapid. Generally the hazard of erosion is severe.

Use and management.—Strong slopes limit these soils for cultivation. They are probably best used for semipermanent hay or pasture, or for rotations in which row crops are grown no oftener than 1 year in 5 or 6. The actual length of the rotation depends on the management practiced. Alfalfa, bromegrass, orchardgrass, and other hay and pasture plants are well suited. A long-lived variety of alfalfa is best. Corn and oats can be grown, but yields are not high.

If the soils are stripcropped, a suggested rotation is a year of a row crop, a year of small grain, and 4 years of meadow. If the soils are terraced, a rotation made up of a year of a row crop, a year of small grain, and 3 years of meadow is suggested.

Because these soils erode readily if row cropped, they need to be cultivated on the contour. Terraces are impracticable on the stronger slopes, but they can be used in some areas.

Fertilizer should be applied in amounts that are based on soil tests.

MANAGEMENT GROUP 15(Vw)

In management group 15 are poorly drained and imperfectly drained soils and a land type, all of which are on nearly level bottom lands. The soils are—

- Alluvial land.
- Colo silt loam, channeled.
- Colo silty clay loam, channeled.
- Huntsville silt loam, channeled.
- Wabash silty clay, channeled.

Sediment is deposited on these soils during occasional floods, and they are cut up by oxbows and other stream channels. The soils of this group are well supplied with plant nutrients and organic matter.

Use and management.—These soils are potentially good cropland, but, unless flooding is controlled, artificial drainage is provided, and stream channels are straightened, they are seldom suitable for cultivation. They are probably best used for pasture. In most areas it is generally worth while to improve pastures. The amounts of fertilizer to apply should be based on soil tests. Canarygrass is suitable where silt is deposited and where water is apt to stand for several days. Birdsfoot trefoil is suitable for all areas except those that are timbered, those on which water stands for long periods, and those where siltation is heavy. A mixture of bluegrass and birdsfoot trefoil provides excellent pasture and usually can be established without great difficulty.

MANAGEMENT GROUP 16(VIe)

Management group 16 consists of steep soils that are suitable for pasture or trees. These soils are low in productivity. They are—

- Clarion loam, 20 to 30 percent slopes, moderately eroded.
- Lester soils, 20 to 30 percent slopes.
- Storden loam, 20 to 30 percent slopes, severely eroded.

All of these soils erode readily if they are cultivated. They are generally low in available nitrogen, in available phosphorus, and in organic matter. The moisture-holding capacity is fairly good, but the amount of available moisture may be limited because of rapid runoff.

Use and management.—The use of these soils is limited by strong slopes or eroded condition. They are not suitable for grain. They are best used for pasture or trees. If they are used for pasture, alfalfa and bromegrass are the best plants. The alfalfa grown should be a long-lived variety. In most places it is practical to improve pastures by reseeding with an alfalfa-bromegrass mixture. Preparing a seedbed on the steep slopes is difficult, and farm machinery should be operated carefully.

Phosphate fertilizer is needed in most areas. The application of fertilizer or lime should be based on soil tests.

Areas used for producing timber should not be grazed. Undesirable trees ought to be cut to allow better growth of desirable trees.

MANAGEMENT GROUP 17(VIs)

Management group 17 consists of rolling to hilly soils that are droughty and low in productivity. They are—

- Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded.
- Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded.
- Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded.
- Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded.
- Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded.

These soils have a low moisture-holding capacity. They erode easily if cultivated. They are generally low in available nitrogen and phosphorus and low in organic matter.

Use and management.—The use of these soils is limited by strong slopes and droughtiness. They are not suitable for grain. They are best used for pasture or, perhaps, trees. Bluegrass can be grown, but a mixture of bromegrass and a long-lived variety of alfalfa will give better yields. Establishing new seedings may be difficult because of the sandy texture. Tillage practices that leave crop residues on the surface and the addition of strawy manure after seeding will help protect young plants from damage by blowing sand and will temporarily increase the moisture-supplying capacity. Grazing should be controlled, to help maintain good stands of pasture plants.

Phosphate fertilizer will be needed in most areas. The application of fertilizer or lime should be based on soil tests.

Alternative uses for these soils are timber and wildlife.

MANAGEMENT GROUP 18(VIIe)

Management group 18 consists of hilly and steep upland soils that are subject to severe erosion if unprotected. They are suitable for use as woodland and for limited use as pasture. These soils are low in productivity. They are—

Clarion loam, 30 to 50 percent slopes.
Hayden soils, 20 to 50 percent slopes.
Lester soils, 30 to 50 percent slopes.
Storden loam, 30 to 50 percent slopes, severely eroded.

All these soils are subject to erosion. They are low in nitrogen, in available phosphorus, and in organic matter.

Use and management.—The use of these soils is limited by their steep slopes, sandy nature, or eroded condition. They are not suitable for grain but are suitable for alfalfa, bromegrass, or birdsfoot trefoil. They are best for permanent pasture or trees. Renovating pastures by using ordinary farm equipment is almost impossible. Slopes that are too steep to be worked with ordinary farm equipment might be renovated by using crawler-type tractors. Grazing should be restricted to maintain a good growth. Woodland should not be grazed. These soils can also be used as wildlife habitats.

Formation, Classification, and Description of Soils

This section discusses soil genesis and morphology and the classification of the soils of Humboldt County by great soil groups. It presents detailed descriptions of soil profiles at specific locations and presents laboratory data on selected soils.

Soil Genesis and Morphology

Soil genesis is the mode of origin of the soil, with special reference to the processes responsible for the development of the solum, or true soil, from the parent material.

Morphology is the physical constitution of the soil, including the texture, structure, consistence, color, and other physical and chemical properties of the horizons that make up the soil profile.

The kind of soil that develops depends on the interaction of parent material, climate, relief, vegetation, and time. These combined factors affect soil formation and give the soil distinct horizons. During the process of soil formation, minerals disintegrate, new minerals and new chemical compounds form, organic matter accumulates and decomposes, and materials in suspension and solution move downward in the soil and are partly removed by drainage water.

Soil morphology in Humboldt County is expressed by both faint and prominent horizons. The Storden, Clarion, Nicollet, Webster, and Glencoe soils have faint horizons. The Rolfe, Orio, Ames, and Cullo soils have prominent horizons. Soils that have intermediate horizonation are the Hayden, Dundas, and LeSueur. Some soils have a marked difference between the texture of the solum and the texture of the underlying D horizon. These soils are the Farrar, Waukegan, Kato, Marshan, and Dickinson, bench position.

Horizon differentiation in the soils of Humboldt County is the result of one or more of the following processes: (1) Accumulation of organic matter; (2) leaching of calcium carbonates and bases; (3) formation and translocation of silicate clay minerals; (4) reduction and transfer of iron; and (5) a process not entirely understood but considered to be accumulation of calcium carbonates. Most of the soils have been affected by two or more of these processes.

Most soils in Humboldt County have some organic matter accumulation, which forms an A_1 horizon. The A_1 horizons in the organic soils of Humboldt County are 20 to 60 percent organic matter. Most of the soils that developed under prairie vegetation in Humboldt County are relatively high in organic matter, compared with soils that developed under prairie in other regions. Some of the mineral soils that are high in organic matter (dominantly humus) are the Glencoe, Nicollet, Webster, Okoboji, Wacousta, Wabash, and Colo soils. They have thick A_1 horizons. The Lamont, Hayden, Orio, and Lakeville soils have faint, thin A_1 horizons. Many soils in this county are intermediate in content of organic matter.

Leaching of calcium carbonates and bases has occurred in many soils in this county. It has taken place, generally before and during the translocation of silicate clay minerals, in all the Gray-Brown Podzolic soils, Brunizems, and Planosols. Most of the soils in Humboldt County—for example, the Clarion, Nicollet, and Webster soils—are only slightly leached, and leaching has not greatly affected horizon differentiation. The Rolfe, Orio, Ames, Hayden, and Dundas soils generally have more strongly leached profiles and an evident accumulation of silicate clays in the B horizon.

There is an accumulation of carbonates in the surface soils and subsoils of the Harpster soils and of Webster silty clay loam, calcareous variant. The horizonation is faintly expressed in these soils. The calcium carbonate equivalent of the Harpster soils ranges from 10 to 40 percent but is dominantly 15 to 25 percent. The accumulation of calcium carbonates in similar soils has been studied by Redmond and McClelland (*10*).

The translocation of silicate clay minerals has contributed to prominent horizonation in the Rolfe, Orio, Hayden, Ames, and Dundas soils. The B horizons generally have dark-colored clay coatings on the ped faces and clay coatings along root channels. The eluviated A_2 horizon has platy structure and is lower in clay and normally lighter colored than the B horizon. Leaching of bases and translocation of clay have been more important processes in horizon differentiation in these soils than the accumulation of organic matter.

Gleying, or the process of reduction and transfer of iron (*17*), is evident in the poorly drained and very poorly drained soils. The Glencoe, Webster, Marshan, Colo, Wabash, Harpster, and Dundas soils have gleyed (B_g) horizons. The B_g horizons are gray, which indicates the reduction and loss of iron. In some soils, there are reddish-brown iron concretions. The C horizons ordinarily are not gleyed, and the boundary is gradual between the gleyed B horizon and the C horizon.

Laboratory data

Laboratory data for profiles of 6 soils are presented in tables 6, 7, and 8.

Factors of soil formation

In the following paragraphs, the five factors of soil formation are discussed in relation to the soils of Humboldt County.

Parent material.—Soils in Humboldt County have developed in glacial till, other kinds of glacial drift, alluvium, organic deposits, and wind-deposited sands. These soil materials are underlain at variable depths by Kinderhook and Saint Louis limestone deposits.

Humboldt County was covered by the Late Wisconsin glaciation. This ice sheet left a deposit of glacial drift 10 to 60 feet thick over the bedrock. (See Physiography, p. 1.) The major soils that developed from glacial till are the Storden, Clarion, Nicollet, Hayden, Lester, and LeSueur. The Lakeville soils developed in morainic areas where sandy and gravelly knobs are surrounded by glacial till. The Garmore soils developed from glacial till in an area where limestone bedrock is at depths of 10 to 20 feet.

The Webster soils developed from glacial till and from glacial outwash or reworked glacial till overlying glacial till (*20*). The Glencoe, Okoboji, Wacousta, Orio, Cullo, and Rolfe soils (*11*) developed from glacial outwash, reworked glacial till, and outwash materials, or, perhaps, local alluvium. (The Rolfe, Okoboji, Glencoe, and Wacousta soils have been studied in detail by E. M. Richlen. See table 6.)

Within Humboldt County there is a wide range in the texture of alluvium because of differences in the materials from which it came and in the time of deposition. Alluvial soils are extensive along the major streams. The land type, Alluvial land, is composed of recent deposits. The alluvium from which the Waukegan, Kato, and Marshan soils developed is thought to have been deposited during and immediately after glaciation. The Huntsville, Colo, and Wabash soils developed from alluvium that is probably of intermediate age.

The Muck and Mucky peat soils developed from accumulations of organic material in old lakebeds or swamps that supported a heavy growth of water-loving plants. The vegetation partly decomposed and accumulated in fairly thick beds under water. Ordinarily glacial drift lies beneath the organic material.

Fine sands apparently blew out of the river bottoms onto the upland slopes. These eolian sands were deposited south and east of the East Fork Des Moines River and the West Fork Des Moines River. The deposits are 2 to 20 feet thick over glacial till. In areas where this fine sandy material is only 2 to 4 feet thick, the Farrar soils formed. The Dickinson and Lamont soils formed where the fine sandy material is dominantly more than 10 feet thick.

Vegetation.—Most of the soils of Humboldt County formed under prairie grasses; some formed under forests composed chiefly of oak, maple, ash, and elm; and some under transitional prairie-forest vegetation. The vegetation in potholes and other depressions was sedges, cattails, rushes, and other similar plants. These plants may not have been the dominant ones all the time since the last glaciation. Lane (*7*) studied the pollen in soil taken from a peat bog in the northern part of Iowa. These studies revealed that pollen, from the base of the soils upward, was that of (1) spruce, (2) fir with spruce and birch, (3) birch with fir and oak, (4) oak and grasses, and (5) grasses of distinctly arid type.

Recent studies on the influence of vegetation on soils that are similar to those in Humboldt County were made by Cardoso,[6] Green (*3*), and McCracken.[7]

Climate.—Available information indicates that the soils in Humboldt County have been developing under a midcontinental, subhumid climate for the last 5,000 years (*14*).

Lane (*7*) assumes that the succession of vegetation is due to changes in climate. From the successions of vegetation, Lane infers three shifts in climate, namely, (1) warming conditions with a change from coniferous to deciduous forms, (2) gradual desiccation of climate just prior to the appearance of grasses, and (3) continued grassland climate, including a second dry period.

The Brunizem and Wiesenboden (Humic Gley) soils of Humboldt County do not have morphological characteristics that indicate that they may have been forested at one time.

Time.—Radiocarbon studies by Ruhe and Scholtes (*15*) indicate that the vegetation and climate, as reported by Lane, occurred less than 11,000 years ago. These studies, and the landscape forms that resulted from glaciation, indicate that the soils in Humboldt County, with correlative temperatures and moisture regimes of approximately 11,000 to 5,000 years ago, were conducive to forest vegetation. Since that time this area has been in an environment favorable for prairie. A previous cycle of forest influence is not indicated in the morphology of the Brunizems and Wiesenbodens in Humboldt County.

Topography.—Topography is an important factor in soil formation because of its effect on drainage, runoff, and erosion. On the whole, the topography of Humboldt County is geologically immature, as evidenced by the large number of potholes and other depressions and by the absence of minor upland streams. Areas adjacent to the major streams are dissected but have very little headward extension. Most of Humboldt County is nearly level to rolling. A high percentage of the soils in the nearly level areas are poorly drained. A high percentage of the soils in the rolling areas are well drained.

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[6] CARDOSO, J. SEQUENCE RELATIONSHIPS OF CLARION, LESTER, AND HAYDEN SOIL CATENAS. Unpublished Ph. D. thesis. Iowa State University Library, Ames. 1957.

[7] MCCRACKEN, R. J. SOIL CLASSIFICATION IN POLK COUNTY, IOWA. Unpublished Ph. D. thesis. Iowa State University Library, Ames. 1956.

The thickness and color of the A horizon of the Storden, Clarion, and Nicollet soils are directly related to topography. The A horizon becomes thicker and darker colored as the slopes become less steep. The Storden soils are on the steepest slopes, the Clarion on the intermediate slopes, and the Nicollet on nearly level topography. The thickness of the solum also increases, from Storden to Clarion to Nicollet. The Webster and Glencoe soils are also a part of the topographic sequence. The Webster soils are nearly level and the Glencoe soils are in depressions. Drainage is also directly related to the slope; the Storden soils are well or excessively drained, the Glencoe are very poorly drained, and the Nicollet soils are nearly optimum in natural drainage.

TABLE 6.—*Laboratory data for profiles of Rolfe silt loam, Okoboji silt loam, Glencoe silty clay loam, and Wacousta silt loam, Humboldt County, Iowa* [1]

[Absence of figure means percentage not determined]

Horizon designation	Depth	Size of particles (in microns)				pH	Total nitrogen	Total carbon	Bulk density	Total pore space	Capillary porosity
		Sand (>50)	Coarse silt (20 to 50)	Fine silt (2 to 20)	Clay (<2)						
Rolfe silt loam (P–521):	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
A_p	0 to 9	17.0	23.8	33.2	26.0	6.3	0.341	4.36	1.0	57.1	44.7
A_2	9 to 16	23.5	23.5	38.2	14.8	5.8	.055	1.00	1.4	44.7	38.3
A_3–B_{g1}	16 to 20	18.5	22.4	33.0	26.1	6.0	.054	.73			
B_{g21}	20 to 26	17.2	16.3	23.2	43.3	6.1	.066	.66	1.37	42.9	40.4
B_{g22}	26 to 29	32.5	13.4	15.9	38.2	6.4	.047	.39			
B_{g23}	29 to 36	27.2	10.2	20.0	42.6	6.7	.042	.32			
B_{g31}	36 to 41	45.0	9.8	15.5	29.7	6.9	.031	.24	1.49	41.2	40.3
B_{g32}	41 to 48	44.0	15.2	16.1	29.0	7.0	.029	.22			
C_{g1}	48 to 55	46.3	12.9	17.8	23.0	7.4	.024	.18	1.47	44.9	40.5
C_{g2}	55 to 62	51.5	13.5	16.8	18.2	7.9	.006	.04			
Okoboji silt loam (P–523):											
A_p	0 to 5	8.4	22.4	40.3	28.9	7.4	.559	4.60	.72		
A_1	5 to 10	8.3	23.0	40.1	28.6	7.5	.567	4.70	.80		
B_1	10 to 16	6.8	23.0	38.1	32.1	7.5	.555	4.60	.84	63.6	53.5
B_{21}	16 to 21	6.2	20.1	38.9	34.8	7.3	.246	1.67	1.01	56.9	43.8
B_{22}	21 to 26	2.7	18.8	41.3	37.2	7.3	.203	1.14	1.16		
B_3	26 to 30	3.5	19.1	41.8	35.6	7.4	.203	.98	1.14		
C_{g1}	30 to 34	1.6	19.5	44.6	34.3	7.5	.068	.32			
C_{g2}	34 to 42	1.5	27.1	44.3	27.1	7.5	.042	.19			
C_{g22}	42 to 49	5.4	26.1	42.5	26.0	7.6	.033	.15			
Glencoe silty clay loam (P–524):											
A_p	0 to 7	8.6	22.8	34.0	34.6	7.0	.479	5.52			
A_{11}	7 to 11	8.7	22.9	33.4	35.0	7.0	.456	5.28	1.07		
A_{12}	11 to 14	10.3	29.3	30.4	30.0	7.1	.262	2.31	1.18	53.6	45.6
A_{13}	14 to 17	11.2	27.3	29.5	32.0	7.1	.182	1.62			
A_3	17 to 20	8.4	23.0	33.3	35.3	7.1	.142	1.42			
B_1	20 to 23	6.2	20.0	35.8	38.0	7.2	.114	1.19			
B_{21}	23 to 26	6.1	17.6	36.0	40.3	7.2	.106	1.04	1.23	51.9	44.8
B_{22}	26 to 30	6.0	19.4	34.8	39.8	7.2	.104	.89	1.20	52.7	44.4
B_{23}	30 to 34	5.5	17.2	37.1	40.2	7.2	.108	.77	1.23		
B_{31}	34 to 38	4.9	15.9	40.6	38.6	7.3	.124	.58	1.21		
B_{32}	38 to 44	4.5	15.1	41.5	38.9	7.3	.128	.47			
B_{33}	44 to 49	3.3	15.7	42.8	38.2	7.4	.131	.45			
C_{g2}	49 to 56	2.9	20.3	47.3	29.5	7.6	.073	.35			
Wacousta silt loam (P–522):											
A_p	0 to 8	11.2	29.4	34.4	25.0	7.2	.435	3.92	1.05	57.3	45.3
A_3B_1	8 to 12	10.0	24.2	34.0	31.8	7.3	.156	1.33	1.36	42.4	41.0
B_{g2}	12 to 20	4.3	28.4	30.2	37.1	7.4	.071	.44	1.22	48.7	45.7
C_{g1}	20 to 26	3.2	32.8	31.0	33.0	7.7	.039	.23	1.28		
C_{g2}	26 to 33	6.6	36.2	31.9	25.3	8.1	.031	.18			

[1] RICHLEN, E. M. PROFILE CHARACTERISTICS OF DEPRESSION TOPOGRAPHY SOILS IN HUMBOLDT COUNTY, IOWA. Unpublished master's thesis. Iowa State University Library, Ames. 1957.

TABLE 7.—*Partial data on physical and chemical properties, Dickinson fine sandy loam, Humboldt County, Iowa* [1]

Horizon designation	Depth	pH	Size of particles (in millimeters): Sand 2 to 1	Sand 1 to 0.5	Sand 0.5 to 0.25	Sand 0.25 to 0.1	Sand 0.1 to 0.05	Clay <0.002	Silt 0.002 to 0.05	Exchangeable cations (meq./100 gm. of soil): H	Ca	Mg	K	Free Fe	N
	Inches		*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*					*Percent*	*Percent*
A_1	0 to 10	7. 1	0. 4	9. 4	21. 2	30. 1	8. 5	12. 5	17. 8	0. 3	9. 9	2. 2	0. 19	0. 35	0. 14
B_1	10 to 15	6. 5	. 5	9. 8	21. 6	29. 7	8. 2	14. 4	15. 7	1. 1	7. 4	2. 2	. 16	. 42	. 10
B_2	15 to 18	5. 9	. 4	8. 5	21. 3	34. 3	10. 8	13. 0	11. 5	1. 4	5. 6	1. 6	. 17	. 40	. 06
B_3	18 to 30	6. 1	. 4	6. 6	19. 7	42. 5	14. 0	11. 4	5. 3	. 7	4. 7	1. 7	. 19	. 44	. 03
C_1	30 to 40	6. 2	. 8	11. 9	26. 7	41. 6	9. 3	6. 0	3. 6	1. 0	2. 5	1. 2	. 16	. 26	. 01
C_2	40 to 50	5. 6	. 9	10. 6	25. 8	43. 3	10. 0	5. 5	4. 0	. 8	2. 4	1. 0	. 15	. 24	. 00
C_3	50 to 60	5. 9	. 6	7. 7	21. 6	48. 4	13. 9	4. 0	4. 2	. 8	2. 3	1. 0	. 17	. 23	. 00

[1] See PHYSICAL AND CHEMICAL PROPERTIES OF SOME IOWA SOIL PROFILES WITH CLAY-IRON BANDS (*2*).

TABLE 8.—*Laboratory data for Webster clay loam, Humboldt County, Iowa* [1]

Horizon designation	Depth	Particle size (in millimeters): Sand (all sizes)	Silt 0.002 to 0.05	Clay <0.002	Total N [2]	Total organic matter	Exchangeable cations (meq./100 gm. of soil): H	Ca	Mg	K
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*				
A	0 to 8	26. 7	39. 1	34. 2	0. 404	7. 1	2. 9	32. 2	7. 7	0. 3
	8 to 13	27. 8	38. 5	33. 7	. 387	6. 4	3. 5	29. 8	7. 9	. 4
	13 to 17	29. 6	35. 6	34. 8	. 207	3. 3	4. 0	22. 9	7. 1	. 4
B	17 to 21	33. 0	33. 0	34. 0	. 150	1. 9	4. 0	20. 3	6. 0	. 3
	21 to 26	38. 0	30. 3	31. 7	. 109	. 9	3. 0	19. 0	6. 4	. 3
C_1	26 to 31	40. 1	31. 8	28. 1	. 082	. 5	. 4	26. 8	5. 9	. 3
C_2	31 to 37	40. 2	35. 6	24. 2	. 071	. 3	. 0	28. 5	4. 6	. 2
	37 to 43	36. 7	39. 3	24. 0	(3)	. 1	. 0	28. 7	4. 6	. 3
	43 to 50	36. 2	39. 2	24. 6	(3)	. 1	. 0	29. 2	4. 5	. 3
	50 to 60	39. 9	35. 8	24. 3	(3)	. 1	. 0	27. 2	4. 7	. 2

[1] See UNDERSTANDING IOWA SOILS (*18*).
[2] CARDOSO, J. SEQUENCE RELATIONSHIPS OF CLARION, LESTER, AND HAYDEN SOIL CATENAS. Unpublished Ph. D. thesis. Iowa State University Library, Ames. 1957.
[3] Not determined.

Classification of Soils

For the purpose of comparing the soils of Humboldt County with soils elsewhere, soil series with certain fundamental characteristics in common are grouped together (*16*).

The great soil groups of Humboldt County are Brunizems, Wiesenbodens, Planosols, Gray-Brown Podzolic soils, Bog soils, Regosols, and Lithosols. The soil series are classified into these great soil groups as follows:

Great soil group	*Series*
Brunizems	Ankeny.
	Clarion.
	Dickinson.
	Farrar.
	Garmore.
	Kato.
	Lakeville.
	Nicollet.
	Truman.
	Waukegan.
Brunizems that intergrade to Alluvial soils.	Copas.
	Huntsville.
	Okoboji, imperfectly drained variant.
	Plattville.
	Terril.
Wiesenbodens	Harpster.
	Marshan.
	Wabash.
	Wacousta.
	Webster.
Wiesenbodens that intergrade to Alluvial soils.	Colo.
	Glencoe.
	Okoboji.
Planosols	Ames.
	Cullo.
	Orio.
	Rolfe.
Planosols that intergrade to Wiesenbodens.	Dundas.
Gray-Brown Podzolic soils	Hayden.
	Lamont.
Gray-Brown Podzolic soils that intergrade to Brunizems.	Lester.
	LeSueur.
Bog soils	Muck.
	Mucky peat.
Regosols	Storden.
Lithosols	Sogn.

Brunizems (Prairie soils) develop under prairie vegetation. They have dark-colored surface soils (A horizons) that, compared with the parent material, are relatively high in organic matter. The amount of organic matter decreases gradually with depth. In Humboldt County, the Brunizems have faint horizon differentiation, as evidenced by the gradual decrease in organic matter from the surface soil to the subsoil and by the brownish subsoils (B horizons) with very little increase in the percentage of clay or other textural difference. These Brunizems are slightly acid at the surface to nearly neutral in the subsoil. They are commonly calcareous in the unweathered parent material (C horizons).

The Brunizems in Humboldt County are the soils of the following series: Ankeny, Clarion, Dickinson, Farrar, Garmore, Kato, Lakeville, Nicollet, Truman, and Waukegan. The Copas, Huntsville, Okoboji, imperfectly drained variant, Plattville, and Terril soils are Brunizems that intergrade to Alluvial soils.

Wiesenbodens (Humic Gley soils) develop under poor natural drainage. In Humboldt County, Wiesenbodens have thick, black to very dark gray A horizons, generally 15 to 20 inches thick; slightly developed B horizons, generally dark colored in the upper part; and gleyed horizons, commonly light olive gray and strongly mottled, below the middle or lower B horizons. These soils in Humboldt County are young soils that do not have as strongly expressed characteristics as Wiesenbodens elsewhere. The Wiesenbodens in Humboldt County are the Harpster, Marshan, Wabash, Wacousta, and Webster soils. The Colo, Glencoe, and Okoboji soils developed from alluvial material or reworked glacial material. They are classified as Wiesenbodens that intergrade to the Alluvial group.

Planosols have one horizon that is much higher in clay, more compact, or more strongly cemented than the horizon immediately above or below it. In Humboldt County, they develop under poor natural drainage and have grayish, leached A_2 horizons and strongly developed, gleyed, genetic-claypan B horizons. The claypan is plastic and only slightly pervious.

The Planosols in Humboldt County are the Ames, Cullo, Orio, and Rolfe soils. The Dundas soils are Planosols that intergrade to Wiesenbodens.

In Humboldt County, Gray-Brown Podzolic soils develop under forest vegetation. They have thin, light-colored A_1 horizons, brownish to grayish A_2 horizons, and brownish B horizons that have an accumulation of clay. They are acid throughout. Gray-Brown Podzolic soils in Humboldt County are the Hayden and Lamont soils. Lester and LeSueur soils are Gray-Brown Podzolic soils that intergrade to Brunizems.

Bog soils have mucky or peaty surface horizons and are underlain by gray mineral soil. They develop chiefly under swamp-forest vegetation, mostly in humid or subhumid climates. The Bog soils in Humboldt County have dark-brown to black, organic A horizons that are 15 to 50 inches thick. They are underlain by gleyed, stratified, mineral horizons. Muck and Mucky peat are Bog soils.

Regosols lack B horizons. The A horizons are thin. Few, if any, clearly expressed soil characteristics have developed. The parent material is unconsolidated. In Humboldt County, Regosols generally have steep slopes on which geologic erosion has nearly kept pace with soil development. The Storden soils are Regosols.

Lithosols also lack B horizons, but they are underlain by bedrock rather than by unconsolidated parent material. They have thin A horizons and very little horizon differentiation. The only Lithosols in Humboldt County are the Sogn soils.

Descriptions of Soil Series and Soil Profiles

The soils of the county are described in this section. Following each series description is a description of a profile of at least one type of that series, at a specific location. The nomenclature is in accordance with that in the Soil Survey Manual.

AMES SERIES

The soils of the Ames series are Planosols that developed under trees from friable, calcareous, Late Wisconsin glacial till of loam texture. They are poorly drained and have very slow permeability. The A_1 horizon ranges from 3 to 6 inches in thickness. It may be loam to silt loam in texture and dark gray (10YR 4/1)[8] to very dark gray (10YR 3/1) in color. The A_2 horizon ranges from 10 to 15 inches in thickness, from light silt loam to light loam in texture, and from dark gray (10YR 4/1) to gray (10YR 6/1) in color. The B horizon ranges from heavy clay loam or gritty silty clay loam to clay.

Although ranges overlap, the Ames soils generally have a lighter colored A_1 horizon, a thicker A_2 horizon, and a finer textured B horizon than Dundas soils.

Ames loam (SW¼NE¼ sec. 4, T. 92 N., R. 28 W.):

A_p 0 to 5 inches, very dark gray to dark gray (10YR 3.5/1), dark-gray (10YR 4/1, dry), medium silt loam; moderate, thin, platy structure; light-gray (10YR 6/1, dry) coatings on plates; friable when moist; medium acid; clear boundary.

A_{21} 5 to 9 inches, dark-gray (10YR 4/1), gray (10YR 5/1, dry), medium loam: moderate to strong, thin, platy structure; medium acid; friable when moist; clear boundary.

A_{22} 9 to 16 inches, gray (10YR 5/1), light-gray (10YR 6/1, dry), light loam; moderate, thick, platy breaking to moderate, medium, platy structure; light-gray (10YR 7/1) and white (10YR 8/1) coatings on plates; strongly acid; slightly hard when dry; clear boundary.

$A_{23}B_1$ 16 to 21 inches, light silty clay loam or clay loam; very dark gray (10YR 3/1) ped coatings, ped interiors gray (10YR 5/1); strong, fine and medium, subangular blocky structure; streaks and flakes of light gray (10YR 6/1) throughout interior of peds; strongly acid; firm when moist; gradual boundary.

B_{21} 21 to 26 inches, mixed very dark gray (10YR 3/1) to dark-gray (10YR 4/1) heavy silty clay loam to clay loam; moderate, medium, prismatic breaking to strong, fine and medium, subangular blocky structure; strongly acid; firm when moist; clear boundary.

B_{22} 26 to 36 inches, mixed dark-gray (10YR 4/1) and very dark gray (10YR 3/1) medium clay loam; moderate, coarse blocky structure; many, fine, distinct, olive-gray (5Y 5/2) mottles; some discontinuous clay films along cleavage planes; strongly acid; firm when moist; gradual boundary.

B_{23} 36 to 48 inches, olive-gray (5Y 5/2) heavy silty clay loam to clay loam; weak, coarse, blocky structure; many, fine, distinct, dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) mottles; clay films on ped surfaces; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on ped surfaces; strongly acid; firm when moist; gradual boundary.

B_3 48 to 52 inches, mixed olive-gray (5Y 5/2) and olive (5Y 5/3) light clay loam; moderate, coarse, subangular blocky structure; common, medium, distinct, dark-gray (10YR 4/1) and few, fine, prominent, dark reddish-brown (5YR 3/4) mottles; many dark-gray (10YR 4/1) coatings in former root channels; few, discontinuous clay films on ped surfaces; strongly acid; slightly firm when moist; gradual boundary.

C_1 52 to 65 inches, brown (10YR 5/3) loam; very weak, coarse, subangular blocky structure to massive; medium acid; friable when moist.

ANKENY SERIES

The soils of the Ankeny series are Brunizems that developed on foot slopes, under grass, from moderately coarse textured colluvial material. They are somewhat excessively drained.

The A horizon is 15 to 30 inches thick and is light to heavy sandy loam. The B horizon is not always distinguishable, but, in some areas, it ranges from sandy loam to light sandy clay loam or light clay loam. The C horizon is loamy sand to sandy loam.

[8] The Munsell notations are for colors of moist soil unless otherwise specified.

The Ankeny soils are better drained than the Terril soils and are coarser textured throughout. They have a thicker A horizon than the Dickinson soils.

Ankeny sandy loam (NE¼NW¼ sec. 6, T. 92 N., R. 30 W.):

A_{1p} 0 to 6 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; very friable when moist.

A_{12} 6 to 26 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; very friable when moist.

B_1 26 to 36 inches, very dark grayish-brown (10YR 3/2) light sandy clay loam; very weak, medium, subangular blocky structure; friable when moist.

B_2 36 to 45 inches, very dark grayish-brown (10YR 3/2) light clay loam; very weak, medium, blocky structure; friable when moist.

C_1 45 to 50 inches, dark grayish-brown (10YR 4/2) sandy loam; massive; very friable when moist.

CLARION SERIES

The soils of the Clarion series are well-drained, moderately permeable Brunizems. They developed under grass, on the uplands, from friable, calcareous loam till of Late Wisconsin age. The slopes commonly range from 2 to 12 percent and generally are convex. The Clarion soils are acid throughout the solum, and the depth to calcium carbonates is 24 to 60 inches.

The steeper the slope, the thinner and lighter colored the A horizon and the fainter the B horizon. The B horizon is loam to heavy loam, 15 to 25 inches thick. The parent material is loam in which small pockets of sand and gravel may occur. Generally, the Clarion soils are associated with the imperfectly drained Nicollet soils and the poorly drained Webster soils.

The Clarion soils that have a thin solum have a thinner B horizon than other Clarion soils. They are on the uplands and generally are surrounded by other Clarion soils. They have convex slopes of 2 to 9 percent. The depth to calcium carbonates is only 12 to 24 inches. The C horizon is calcareous. The A and B horizons are light loam to heavy loam. These thinner Clarion soils differ from the Storden soils in having a B horizon and in not being calcareous within 12 inches of the surface.

Clarion loam (NE¼NE¼ sec. 34, T. 93 N., R. 28 W.):

A_1 0 to 6 inches, very dark brown (10YR 2/2) loam; moderate, medium, granular structure; friable when moist.

A_3 6 to 8 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) loam; weak, medium, granular structure; friable when moist.

B_1 8 to 12 inches, dark-brown (10YR 3/3) loam; weak, fine, subangular blocky structure; very dark brown (10YR 2/2, moist) stains; friable when moist.

B_2 12 to 21 inches, dark-brown (10YR 4/3) heavy loam; weak, fine, subangular blocky structure; friable when moist.

B_3 21 to 26 inches, mixed dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) loam; weak, fine, subangular blocky structure; friable when moist.

C_1 26 to 40 inches, dark yellowish-brown (10YR 4/4) loam; massive; friable when moist.

C_2 40 inches+, mixed yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) loam; massive; calcareous; friable when moist.

Clarion loam, thin solum (NW¼SW¼ sec. 15, T. 93 N., R. 30 W.):

A_p 0 to 6 inches, very dark brown (10YR 2/2) loam; weak, very fine, granular structure; friable when moist.

A_3 6 to 9 inches, mixed very dark grayish-brown (10YR 3/2) and dark yellowish-brown (10YR 4/4) loam; weak, fine, granular structure; friable when moist.

B 9 to 15 inches, mixed dark-brown (10YR 3/3) and dark yellowish-brown (10YR 4/4) loam; weak, very fine, granular structure; friable when moist.

C_1 15 to 21 inches, yellowish-brown (10YR 5/4) loam; massive; friable when moist.

C_2 21 to 60 inches, yellowish-brown (10YR 5/4) loam; massive; calcareous; friable when moist.

COLO SERIES

The soils of the Colo series are dark-colored, medium textured and moderately fine textured Wiesenbodens that developed from alluvium washed from the Late Wisconsin till plain. The Colo soils in Humboldt County intergrade to the Alluvial group. They are on first bottoms adjacent to major and minor streams. They are poorly drained and moderately slowly permeable. Generally, the solum is slightly acid throughout. The native vegetation was grass.

Colo silt loams.—Recent floods have deposited soil material on Colo silt loams. The recent deposits are lighter in color and texture than the underlying material. The part of the A horizon in the recent deposits varies from 9 to 20 inches in thickness and from light loam to heavy silt loam in texture. Where there is an A horizon below the recent deposits, it is loam to silty clay loam. The B horizon ranges from light clay loam to heavy silty clay loam. Below a depth of 45 inches, in many areas, there is a D horizon of loamy sand to sand.

Colo silt loam (SE¼SE¼ sec. 4, T. 93 N., R. 29 W.):

A_p 0 to 9 inches, very dark gray (10YR 3/1) heavy silt loam; weak, fine and very fine, subangular blocky structure; friable when moist; gradual boundary.

A 9 to 16 inches, black (10YR 2/1) heavy silt loam; weak, fine, subangular blocky structure; slightly firm when moist; gradual boundary.

B 16 to 36 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; slightly firm when moist; gradual boundary.

C_1 36 to 45 inches, dark-gray (2.5Y 4/) light clay loam; massive; slightly firm when moist; clear boundary.

C_2 45 to 55 inches, dark-gray (5Y 4/) loam; massive; common, medium, faint, olive (5Y 4/3, moist) mottles; friable when moist.

Colo silty clay loams.—The Colo silty clay loams have an A horizon of medium to heavy silty clay loam, 20 to 35 inches thick. The B horizon is silty clay loam to light silty clay. In many places there is a D horizon of loamy sand to sandy loam below a depth of 45 inches. The Colo silty clay loams have a darker colored and finer textured surface horizon than the Colo silt loams.

Colo silty clay loam (NE¼NE¼ sec. 4, T. 93 N., R. 27 W.):

A_{1p} 0 to 6 inches, black (10YR 2/1) medium silty clay loam; very coarse, crumb (cloddy) structure; slightly firm; diffuse boundary.

A_{12} 6 to 11 inches, black (10YR 2/1) medium silty clay loam; weak, medium, subangular blocky structure; slightly firm when moist; diffuse boundary.

A_{13} 11 to 20 inches, black (10YR 2/1) medium silty clay loam; weak, fine and medium, subangular blocky structure; some clay films along old root channels; slightly firm when moist; gradual boundary.

A_3 20 to 28 inches, very dark gray (10YR 3/1) medium silty clay loam; weak, fine, subangular blocky structure to massive; clay films along old root channels; firm when moist; gradual boundary.

B_1 28 to 38 inches, mixed dark-gray (5Y 4/1) and very dark gray (5Y 3/1) heavy silty clay loam; weak, fine, subangular blocky structure to massive; few, fine, distinct, yellowish-brown (10YR 5/4) mottles; clay films along root channels; slightly firm when moist; gradual boundary.

B_2 38 to 50 inches, mixed olive (5Y 5/3) and olive-gray (5Y 5/2) heavy silty clay loam; massive; common, fine, distinct, dark-brown (7.5YR 4/4) mottles; dark-gray (5Y 4/1) crayfish holes; clay films along root channels; many iron and manganese concretions; firm when moist.

D 50 inches+, dark-gray (10YR 4/1) loamy sand; massive; friable when moist.

COPAS SERIES

The Copas soils are well-drained Brunizems. Those in Humboldt County intergrade to Alluvial soils. These soils developed from gritty alluvium and glacial outwash and are underlain by limestone bedrock at depths of 18 to 30 inches. They are along minor drainageways and on terraces along major streams on the Late Wisconsin till plain. They have moderately rapid permeability. The native vegetation was grass.

The A_1 horizon varies from gritty silt loam to loam in texture and from 6 to 12 inches in thickness. The B horizon is dominantly heavy loam but ranges to light loam containing gravel.

The Copas soils are better drained and shallower over bedrock than the Plattville soils, which are also Brunizems intergrading to Alluvial soils.

Copas loam (SE¼NW¼ sec. 11, T. 91 N., R. 30 W.):

A_1 0 to 7 inches, very dark gray (10YR 3/1) loam; weak, fine, granular structure; very friable when moist; medium acid; clear boundary.

A_3 7 to 11 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, granular structure; few, fine, distinct, dark-brown (10YR 4/3) mottles; friable when moist; medium acid to neutral; gradual boundary.

B_2 11 to 16 inches, mixed dark-brown (10YR 3/3) and very dark grayish-brown (10YR 3/2) heavy loam; weak, fine, subangular blocky structure; friable when moist; medium acid to neutral; gradual boundary.

B_3 16 to 22 inches, mixed dark-brown (10YR 3/3) and dark yellowish-brown (10YR 4/4) coarse gravelly loam; weak, fine, subangular blocky structure to massive; slightly acid to neutral; friable when moist; abrupt boundary.

D 22 inches+, limestone bedrock.

CULLO SERIES

In the Cullo series are poorly drained Planosols that occur throughout the county in depressions and in nearly level areas on the upland till plain. The slopes are zero to about one-half percent. Unlike some other soils in similar positions, the Cullo soils are not rimmed, or surrounded, by Harpster soils.

The Cullo soils developed from calcareous material of Late Wisconsin age—glacial till, waterworked glacial till, or local alluvium. The native vegetation was swamp grasses and sedges. These soils are slowly to very slowly permeable. They are acid throughout the solum.

The A_1 horizon varies from 10 to 15 inches in thickness, from light to medium silty clay loam in texture, and from black (10YR 2/1 or 5Y 2/1) to very dark gray (10YR 3/1) in color. The A_2 horizon is weakly developed. It ranges from 3 to 5 inches in thickness and from medium silt loam to light silty clay loam in texture. The color of the A_2 horizon ranges from very dark gray (10YR 3/1 flecked with gray (10YR 5/1), to dark gray (10YR 4/1) flecked with gray (10YR 6/1).

The B_g horizon ranges from 15 to 25 inches in thickness, from heavy clay loam to heavy silty clay loam in texture, and from very dark gray (5Y 3/1) to olive-gray (5Y 4/2) or dark grayish-brown (2.5Y 4.2) in color. In this horizon there are discontinuous clay films along the vertical cleavage planes.

The C_g horizon is friable, stratified, glacial drift; it contains layers of silt, coherent sand, and loam and normally is calcareous below a depth of 60 inches.

The Cullo soils generally have a thicker A_1 horizon and a less clayey B horizon than the Rolfe soils. They have a slightly lighter textured A_1 horizon than the Webster soils.

Cullo silty clay loam:

A_1 0 to 13 inches, black (10YR 2/1) light silty clay loam; weak, fine, granular structure; friable when moist; clear boundary.

A_2 13 to 16 inches, mixed very dark gray (10YR 3/1) and dark-gray (10YR 4/1) silt loam; weak, very thin, platy breaking to weak, fine, subangular blocky structure; friable when moist; clear boundary.

B_{g21} 16 to 22 inches, mixed very dark gray (5Y 3/1) and dark olive-gray (5Y 3/2) medium silty clay; moderate, very fine, subangular blocky structure; slightly firm when moist; gradual boundary.

B_{g22} 22 to 28 inches, olive-gray (5Y 4/2) heavy silty clay loam; moderate, medium, subangular blocky structure; common, medium, faint, dark olive-gray (5Y 3/2) mottles; continuous clay films along vertical cleavage planes; firm when moist; gradual boundary.

B_{g23} 28 to 35 inches, olive-gray (5Y 4/2) medium silty clay loam; weak, medium, subangular blocky structure to massive; common, coarse, distinct, olive (5Y 4/4) mottles; discontinuous clay films along vertical cleavage planes; slightly firm when moist; gradual boundary.

C_g 35 to 50 inches, dark-gray (5Y 4/1) loam; massive; common, coarse, distinct, olive (5Y 4/4, moist) mottles; friable when moist.

DICKINSON SERIES

The Dickinson series consists of rapidly to moderately rapidly permeable, excessively drained soils that developed under grass. They are Brunizems. Some of them are on the upland till plain; others are on benches. Those on the upland plain developed from sandy material which was probably wind deposited but included some sandy glacial drift. The slopes are concave and convex.

Dickinson soils on the upland have an A horizon 3 to 14 inches thick. The B horizon ranges from sandy loam to heavy sandy loam in texture and from 10 to 25 inches in thickness. The C horizon is loamy sand or sand, underlain by fine sand and loamy sand. Partial data on physical and chemical properties of Dickinson fine sandy loam are presented in table 7, p. 48.

The Dickinson soils on benches or outwash terraces of Late Wisconsin age are also rapidly permeable and excessively drained. They developed from sandy alluvium, some of which may have been reworked by wind. Generally, these soils are acid throughout the solum, but in a few areas they are calcareous.

The A horizon of Dickinson soils on benches is very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The A and B horizons range from light sandy loam to heavy sandy loam. The C horizon ranges from light sandy loam containing some gravel to gravelly sandy loam. The D horizon, which is below depths of 24 to 45 inches, contains fine, medium, and coarse gravel mixed with coarse sand and shale fragments in stratified layers.

Dickinson fine sandy loam (300 feet south of NW¼-NW¼ sec. 15, T. 93 N., R. 30 W.):

A_1 0 to 10 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, granular structure; very friable when moist.

B_1 10 to 15 inches, mixed very dark grayish-brown (10YR 3/2) and very dark brown (10YR 2/2) sandy loam; very weak, fine, granular structure; very friable when moist.

B_2 15 to 18 inches, mixed dark-brown (10YR 3/3) and very dark brown (10YR 2/2) sandy loam; single grain; very friable when moist.

B_3 18 to 30 inches, dark-brown (10YR 3/3) sandy loam; single grain structure; few very dark brown (10YR 2/2) root channels; very friable when moist.

C_{11} 30 to 40 inches, mixed brown (10YR 4/3) and yellowish-brown (10YR 5/4) loamy sand; loose when moist.

C_{12} 40 to 50 inches, yellowish-brown (10YR 5/4) sand; loose when moist.

C_{13} 50 to 60 inches, light yellowish-brown (10YR 6/4) medium sand; loose when moist.

Dickinson sandy loam, bench position (SE¼NW¼ sec. 34, T. 92 N., R. 29 W.):

A_{1p} 0 to 6 inches, very dark brown (10YR 2/2) sandy loam; weak, medium, granular structure; very friable when moist.

A_{12} 6 to 15 inches, black to very dark brown (10YR 2/1.5) light sandy loam; very weak, medium, granular structure; medium acid; very friable when moist.

B_2 15 to 20 inches, very dark brown (7.5YR 2/2) light sandy loam; very weak, medium, granular structure; medium acid; very friable when moist.

B_3 20 to 25 inches, dark-brown (7.5YR 3/3) loamy sand; single-grain structure; medium acid; loose when moist.

C_1 25 to 44 inches, dark yellowish-brown (10YR 3/4 and 4/4) medium sand; single-grain structure; slightly acid; loose when moist.

D_1 44 to 52 inches, dark yellowish-brown (10YR 3/4 and 4/4) fine and medium gravel; neutral; loose when moist.

D_2 52 to 62 inches, dark-brown (7.5YR 3/2 and 4/4) fine gravel and coarse sand; loose when moist.

DUNDAS SERIES

The soils of the Dundas series are Planosols intergrading to Wiesenbodens. They have developed on the uplands from calcareous loam till of Late Wisconsin age. The soils are poorly drained and are slowly to very slowly permeable. The native vegetation consisted of prairie grasses and trees. Forests have presumably encroached on the prairie fairly recently.

The A_1 horizon ranges from light clay loam to light silty clay loam in texture and from 6 to 12 inches in thickness. The A_2 horizon ranges from light clay loam to light silty clay loam in texture and from 4 to 8 inches in thickness. The B horizon ranges from heavy silty clay loam to light silty clay. The matrix color of the C horizon ranges from grayish brown (2.5Y 5/2) to olive gray (5Y 5/2).

The Dundas soils have a thinner A_1 horizon and finer textured B horizon than the Webster soils. They have a thicker A_1 horizon, thinner A_2 horizon, and generally a less fine-textured B horizon than the Ames soils.

Dundas silty clay loam (NW¼SW¼SW¼ sec. 3, T. 92 N., R. 28 W.):

A_1 0 to 8 inches, black (10YR 2/1) light silty clay loam; moderate, medium, granular structure; medium acid; friable when moist; gradual boundary.

A_2 8 to 13 inches, very dark gray (10YR 3/1) silty clay loam; moderate, medium, granular structure; strongly acid; friable when moist; clear boundary.

B_1 13 to 21 inches, mixed very dark gray (10YR 3/1) and black (2.5Y 2/0) silty clay loam; moderate, fine, subangular blocky structure; very strongly acid; slightly firm when moist; gradual boundary.

B_2 21 to 29 inches, dark-gray (10YR 4/1) silty clay; moderate, medium, subangular structure; many, fine, distinct, olive-gray (5Y 4/2) and olive-brown (2.5Y 4/4) mottles; clay films along root channels and on ped surfaces; very strongly acid; firm when moist; gradual boundary.

B_3 29 to 39 inches, mixed dark grayish-brown (2.5Y 4/2), very dark grayish-brown (2.5Y 3/2), brown (10YR 5/3), and light yellowish-brown (10YR 6/4) heavy silty clay loam; strong, medium, subangular blocky structure; firm when moist; clear boundary.

C 39 to 45 inches, very dark grayish-brown (10YR 3/2), pale-brown (10YR 6/3), and dark-brown (7.5YR 4/4) loam; massive; strongly acid; slightly firm when moist.

FARRAR SERIES

The Farrar soils are somewhat excessively drained Brunizems. They developed on the uplands from sandy eolian material that overlies calcareous glacial till of Late Wisconsin age. The till, a friable, calcareous loam, is 14 to 40 inches from the surface. Farrar soils have moderately rapid permeability. They formed under grass.

The A horizon varies from light sandy loam to medium sandy loam. The B horizon ranges from medium to heavy sandy loam. A sandy loam C horizon is common in places where the till occurs between depths of 30 and 40 inches. The Farrar soils are acid throughout the solum.

Farrar fine sandy loam (NE¼NE¼ sec. 31, T. 92 N., R. 29 W.):

A_1 0 to 7 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, fine, granular structure to single grain; very friable when moist.

A_3 7 to 12 inches, dark-brown (10YR 3/3) sandy loam; weak, fine, granular structure; very friable when moist.

B 12 to 24 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, fine, granular structure; very friable when moist.

D 24 inches+, yellowish-brown (10YR 5/6) loam; massive; friable when moist.

GARMORE SERIES

The Garmore soils are moderately well drained Brunizems. They occur only in the southwestern quarter of the county, in general soil area 3 and adjacent to Clarion soils. The parent material of the Garmore soils is friable, calcareous loam, a glacial till of Late Wisconsin age. Garmore soils are moderately permeable and are leached of carbonates to a depth of about 60 inches. They are underlain by limestone bedrock at depths that probably average between 10 and 20 feet. The slopes are dominantly concave, but some are convex. The native vegetation was prairie grass.

The A horizon varies from gritty silt loam to loam in texture and from 10 to 16 inches in thickness. The B horizon is dominantly light clay loam, but it ranges to heavy loam.

The Garmore soils have a thicker and more acid solum and a more prominent B horizon than the Clarion and Nicollet soils. They are also leached of carbonates to greater depths. They are better drained than the Nicollet soils and less well drained than the Clarion soils, which are generally on convex slopes in areas where they are adjacent to Garmore soils. The topographic position is similar to that of the Webster and Nicollet soils.

Garmore silt loam (NW¼NW¼ sec. 14, T. 91 N., R. 30 W.):

A_{1p} 0 to 6 inches, black to very dark gray (10YR 2.5/1) gritty silt loam intergrading to heavy loam; moderate, medium, granular structure; strongly acid; friable when moist; gradual boundary.

A_{12} 6 to 11 inches, black to very dark gray (10YR 2.5/1) (10YR 3/1, crushed) heavy loam; moderate, medium, granular structure; strongly acid; friable when moist; gradual boundary.

A_3 11 to 15 inches, black to very dark gray (10 YR 2.5/1) light clay loam; weak, fine, subangular blocky structure; many, fine, distinct, very dark grayish-brown (10YR 3/2) mottles; strongly acid; friable when moist; gradual boundary.

B_{11} 15 to 21 inches, mixed very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) light clay loam; moderate, fine, subangular blocky structure; common, fine, faint, very dark gray (10YR 3/1) mottles; strongly acid; slightly firm when moist; gradual boundary.

B_{12} 21 to 25 inches, mixed dark-brown (10YR 4/3) and very dark grayish-brown (10YR 3/2) light clay loam; moderate, fine, subangular blocky structure; common, fine, distinct, very dark gray (10YR 3/1) mottles; strongly acid; slightly firm when moist; gradual boundary.

B_{21} 25 to 30 inches, mixed dark-brown (10YR 4/3) and very dark grayish-brown (10YR 3/2) light clay loam; moderate, medium, subangular blocky structure; few, medium, distinct, very dark gray (10YR 3/1, moist) mottles; medium acid; slightly firm when moist; gradual boundary.

B_{22} 30 to 36 inches, mixed dark grayish-brown (10YR 4/2) and dark-brown (10YR 4/3) light clay loam; moderate to strong, medium, subangular blocky structure; medium acid; slightly firm when moist; gradual boundary.

B_{23} 36 to 43 inches, dark yellowish-brown (10YR 4/4) heavy loam; moderate, fine to medium, subangular blocky structure; dark grayish-brown (10YR 4/2) ped coatings; medium acid; slightly firm when moist; gradual boundary.

B_3 43 to 49 inches, yellowish-brown (10YR 5/4) loam; weak, coarse, subangular blocky structure to massive; common, medium, distinct, dark grayish-brown (10YR 4/2) mottles and ped coatings; slightly acid; friable when moist; gradual boundary.

C_1 49 to 62 inches, yellowish-brown (10YR 5/6) loam; massive; dark grayish-brown (10YR 4/2) ped coatings and few, fine, distinct, grayish-brown (2.5Y 5/2) mottles; many pinhead-size iron and manganese coatings appear on shale particles; slightly acid; friable when moist; clear boundary.

C_2 62 to 75 inches, yellowish-brown (10YR 5/6) loam; massive structure; few, fine, distinct, grayish-brown (2.5Y 5/2) and strong-brown (7.5YR 5/8) mottles; calcareous; friable when moist.

GLENCOE SERIES

In the Glencoe series are very poorly drained soils that developed from calcareous glacial outwash, reworked glacial till and outwash materials, or local alluvium. These soils are classified as Wiesenbodens that intergrade to Alluvial soils. They are in the uplands in basinlike depressions, or potholes, and are most commonly surrounded, or rimmed, by Harpster or calcareous Webster soils. The Glencoe soils are slowly to very slowly permeable. They are neutral to slightly calcareous in the surface soil. Swamp grasses and sedges have been the native vegetation.

The A horizon varies from 18 to 26 inches in thickness and from silty clay loam to light silty clay in texture. The B_g horizon ranges in color from black (2.5Y 2/1) to dark olive-gray (5Y 3/2) and in texture from medium silty clay loam to light silty clay. The C_g horizon ranges from loam to silt loam in texture.

The Glencoe soils have a thicker A horizon and a finer textured B horizon than the Webster soils. They are finer textured throughout than the Okoboji soils, which occupy similar positions.

Laboratory data for the following profile is presented in table 6, p. 47.

Glencoe silty clay loam (100 yards south and 90 yards east of the NW corner of NW¼NW¼ sec. 32, T. 92 N., R. 27 W., Lake Township):

A_{1p} 0 to 7 inches, black (5Y 2/1) silty clay loam; moderate, medium, granular structure; slightly firm when moist.

A_{12} 7 to 11 inches, black (5Y 2/1) silty clay loam; weak, fine, subangular blocky structure; slightly firm when moist.

A_{13} 11 to 14 inches, black (5Y 2/1) light silty clay loam; weak, very thin, platy structure; slightly firm when moist.

A_{14} 14 to 17 inches, black (5Y 2/1) light silty clay loam; weak, very thin, platy structure; slightly firm when moist.

A_3 17 to 20 inches, black (5Y 2/1) silty clay loam; weak, very thin, platy structure; slightly firm when moist.

B_{1g} 20 to 23 inches, black (5Y 2/1, 2/2) heavy silty clay loam; moderate, very fine, subangular blocky structure; firm when moist.

B_{21g} 23 to 26 inches, black (5Y 2/1, 2/2) light silty clay; moderate, very fine, subangular blocky structure; firm when moist.

B_{22g} 26 to 30 inches, black (5Y 2/1, 2/2, moist) light silty clay; moderate, very fine, subangular blocky structure; firm when moist.

B_{23g} 30 to 34 inches, black (5Y 2/1, 2/2) light silty clay; moderate, very fine, subangular blocky structure; firm when moist.

B_{31g} 34 to 38 inches, black (5Y 2/1) to very dark gray (5Y 3/1) heavy silty clay loam; weak, very fine, subangular blocky structure; firm when moist.

B_{32g} 38 to 44 inches, black (5Y 2/1) to very dark gray (5Y 3/1) heavy silty clay loam; weak, very fine, subangular blocky structure; firm when moist.

B_{33g} 44 to 49 inches, very dark gray (5Y 3/1) heavy silty clay loam; weak, very fine, subangular blocky structure with vertical cleavage planes; firm when moist.

C_{2g} 49 to 56 inches, gray (5Y 5/1) to light-gray (5Y 6/1) heavy silt loam; massive; yellowish-brown (10YR 5/6, 5/8) iron mottles; calcareous; occasional snail shells; friable when moist.

HARPSTER SERIES

The Harpster series consists of poorly drained, highly calcareous soils that developed from friable, calcareous, glacial till, outwash, or alluvium of Late Wisconsin age. These soils are Wiesenbodens. They have moderate to moderately slow permeability. Prairie grasses have been the native vegetation. The content of calcium carbonate ($CaCO_3$ equivalent) in the solum ranges from 10 to 30 percent. Some of these soils are on the rims of present or former ponds or lakes, where the depth of water and the thick-growing vegetation furnished a favorable habitat for fresh-water snails. In most places there are snail-shell fragments on the surface and within the upper part of the profile. Thus, the high-lime content of the soils can be attributed, at least in part, to carbonates from snail shells. Some areas of Harpster soils are on stream terraces.

Harpster loams.—These soils developed in glacial till. They occur as rims around depressions, or potholes, or on small rises within depressions. The slope range is ½ to 1½ percent.

The A horizon, 8 to 14 inches thick, is a loam to light clay loam or silty clay loam. The color of this layer varies from dark gray (5Y 4/1) to black (5Y 2/1), but grays predominate. The B horizon ranges from a light clay loam to light silty clay loam. The surface horizon is grayer and less fine textured than the corresponding layer in Webster silty clay loam, calcareous variant. Harpster loams are more poorly drained than Harpster silt loams.

Harpster loam (SE¼SE¼ sec. 4, T. 92 N., R. 28 W.):

A_{1ca} 0 to 6 inches, mixed dark-gray (10YR 4/1) and very dark gray (10YR 3/1) heavy loam; moderate, medium, granular structure; calcareous; snail-shell fragments common on surface; friable when moist.

A_{3ca} 6 to 9 inches, mixed dark-gray (10YR 4/1) and very dark gray (10YR 3/1) heavy loam; weak, medium, granular structure; calcareous; friable when moist.

B_{g1ca} 9 to 18 inches, mixed dark-gray (10YR 4/1) and very dark grayish-brown (2.5Y 3/2) light clay loam; weak, fine and medium, subangular blocky structure; calcareous; slightly firm when moist.

B_{g2ca} 18 to 22 inches, dark-gray (10YR 4/1) light clay loam; very dark grayish-brown (2.5Y 3/2) and dark grayish-brown (10YR 4/2) mottles; very weak, fine, subangular blocky structure; calcareous; slightly firm when moist.

C 22 to 60 inches, mottled grayish-brown (2.5Y 5/2), very dark grayish-brown (2.5Y 3/2), and olive-gray (5Y 5/2) loam; massive; calcareous; friable when moist.

Harpster loams, sand and gravel substratum.—These soils developed from alluvium or outwash materials on stream terraces and on beaches around former lakes. The slopes are ½ to 1½ percent.

The A_1 horizon varies from dark gray (5Y 4/1) to black (10YR 2/1), but grays predominate. The thickness of the A horizon is 7 to 14 inches, and the texture is light loam to heavy loam and, in a very few areas, sandy loam. The B and C horizons range from loam to light clay loam. Below depths of 30 to 50 inches, there is sand, sandy loam, or gravel.

Harpster loam, sand and gravel substratum (SW¼SW¼ sec. 1, T. 93 N., R. 30 W.):

A_{1pca} 0 to 6 inches, black (10YR 2/1) loam; weak, very fine, granular structure; calcareous; friable when moist; gradual boundary.

A_{12ca} 6 to 15 inches, black (10YR 2/1) light clay loam; weak, very fine, granular structure; calcareous; friable when moist; gradual boundary.

B_{g1ca} 15 to 22 inches, very dark gray (10YR 3/1) light clay loam; weak, fine, granular structure to weak, very fine, subangular blocky structure; calcareous; friable when moist; gradual boundary.

B_{g2ca} 22 to 29 inches, grayish-brown (2.5Y 5/2) silty clay loam; weak, very fine, subangular blocky structure; very dark gray (10YR 3/1, moist) worm casts; calcareous; friable when moist; gradual boundary.

C 29 to 39 inches, olive (5Y 5/3) light clay loam; massive; few, fine, faint, light olive-brown (2.5Y 5/6, moist) mottles; calcareous; friable when moist; gradual boundary.

D 39 to 60 inches, olive-gray (5Y 5/2) sandy loam; single-grain; calcareous; loose when moist.

Harpster silt loams.—These are highly calcareous soils that developed from silty glacial outwash or alluvium under prairie vegetation. They are poorly drained to somewhat poorly drained and moderately permeable. They occur in moderately large, nearly level areas on low and high terraces, principally along Prairie Creek in Vernon Township. The associated soils are the Marshan, Kato, Truman, and Waukegan.

The A_1 horizon ranges from 7 to 16 inches in thickness, from light silt loam to heavy silt loam in texture, and from black (10YR 2/1) to dark gray (5Y 4/1) in color. The higher color values reflect a higher content of calcium carbonate. The B horizon ranges from medium silt loam to heavy silt loam.

Harpster silt loams are silt loam throughout, whereas Harpster loams have a clay loam B horizon.

Harpster silt loam (SE¼SW¼ sec. 10, T. 93 N., R. 27 W.):

A_{1ca} 0 to 16 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; calcareous; friable when moist; gradual boundary.

B_{g1ca} 16 to 21 inches, very dark grayish-brown (2.5Y 3/2) silt loam; weak, very fine, granular structure; few, fine, faint, dark grayish-brown (2.5Y 4/3) and many, medium, faint, black (10YR 2/1) mottles; calcareous; friable when moist; gradual boundary.

B_{gca} 21 to 27 inches, mixed light olive-brown (2.5Y 5/4) and very dark grayish-brown (2.5Y 3/2) silt loam; weak, very fine, granular structure; many, medium, faint, black (10YR 2/1) mottles; calcareous; friable when moist; gradual boundary.

B_{g3ca} 27 to 37 inches, light olive-brown (2.5Y 5/4) silt loam; weak, fine, granular structure; few, fine, distinct, dark-brown (10YR 4/3) and gray (5Y 5/1) mottles; many pinholes; calcareous; very friable when moist; gradual boundary.

C_{g1ca} 37 to 48 inches, light brownish-gray (2.5Y 6/2) silt loam; massive but with some laminations; many, medium, prominent, strong-brown (7.5YR 5/6) mottles; many pinholes and root channels; calcareous; very friable when moist; gradual boundary.

C 48 to 52 inches, light brownish-gray (2.5Y 6/2), light-gray 2.5Y 7/2, dry), silt loam; massive; many, medium, prominent, strong-brown (7.5YR 5/6) mottles; abundant iron pipestems; calcareous; friable when moist.

HAYDEN SERIES

In the Hayden series are well-drained Gray-Brown Podzolic soils that developed under hardwood trees from Late Wisconsin till. The till is a friable, calcareous loam. These soils are in the uplands, near the major streams. They have moderately slow permeability. Calcium carbonates are at depths of 40 to 60 inches.

The A_1 horizon is 2 to 7 inches thick and varies from loam to silt loam. The A_2 horizon is 2 to 8 inches thick and varies from light loam to light silt loam. The thickness of the A_1 and A_2 horizons decreases as the slopes increase. The B horizon ranges from medium clay loam to heavy clay loam.

In comparison with Lester soils, the Hayden soils have a thicker A_2 horizon with a more distinctly platy structure and a more developed, finer textured B horizon.

Hayden loam (SW¼NE¼ sec. 4, T. 92 N., R. 28 W.):

A_p 0 to 6 inches, very dark gray (10YR 3.5/1) loam; gray (10YR 5/1) when dry; weak, thin, platy structure; neutral; friable when moist; clear boundary.

A_2 6 to 9 inches, mixed very dark gray (10YR 3.5/1) and dark grayish-brown (10YR 3.5/2) loam; weak to moderate, thin and medium, platy structure; friable when moist; clear boundary.

B_1 9 to 12 inches, dark-brown (10YR 3/3) heavy loam; moderate, fine, subangular blocky structure; slightly acid; friable when moist; clear boundary.

B_{21} 12 to 19 inches, dark-brown (10YR 3/2.5), dark-brown (10YR 3.5/3) when crushed, medium clay loam; strong, fine, subangular blocky breaking to very fine, subangular blocky structure; very dark grayish-brown (10YR 3/2) ped coatings; strongly acid; firm when moist; gradual boundary.

B_{22} 19 to 25 inches, dark-brown (10YR 3/2.5), dark-brown (10YR 3.5/3) when crushed, medium clay loam; weak, medium, subangular blocky structure; dark-brown (7.5YR 3/4) ped coatings; medium acid; slightly firm when moist; gradual boundary.

B_3 25 to 38 inches, dark yellowish-brown (10YR 4/4) gritty clay loam; massive; dark-brown (7.5YR 4/4) ped coatings; common, fine, distinct, grayish-brown (2.5Y 5/2) mottles; medium acid; slightly firm when moist; gradual boundary.

C_1 38 to 50 inches, yellowish-brown (10YR 4.5/4) loam; massive; slightly acid; friable when moist.

HUNTSVILLE SERIES

The Huntsville series consists of dark-colored, imperfectly drained soils that developed from alluvium on first bottoms near streams. These soils are classified as Brunizems that intergrade to Alluvial soils. They are moderately permeable and generally noncalcareous throughout the solum. The native vegetation was mixed prairie grasses and trees.

The A horizon is 8 to 20 inches thick. It ranges from loam to light silty clay loam in texture and from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) in color. Black (10YR 2/1) is included in places. The matrix color of the B horizon ranges from dark brown (10YR 3/3) to light olive brown 2.5Y 5/4). The B horizon ranges from loam to light silty clay loam and may contain stratified layers of sandy loam and silty clay loam. The C horizon varies from loam to sandy loam and generally is stratified

The Huntsville soils are better drained than the Colo soils. The surface horizon is lighter colored and less clayey than the corresponding layer in the Colo soils.

Huntsville silt loam (NW¼NW¼ sec. 33, T. 92 N., R. 28 W.):

A_p 0 to 6 inches, black (10YR 2/1), very dark gray (10YR 3/1) when crushed, silt loam; moderate, coarse, granular structure; slightly acid; friable when moist; gradual boundary.

A_1 6 to 14 inches, black (10YR 2/1) heavy silt loam; weak, fine and very fine, subangular blocky structure; friable when moist; gradual boundary.

A_3 14 to 19 inches, very dark gray (10YR 3/1) light silty clay loam; weak, fine, subangular blocky structure; discontinuous clay films along root channels; slightly acid; friable when moist; gradual boundary.

B_1 19 to 24 inches, mixed black to very dark gray (10YR 2.5/1) and very dark grayish-brown to dark-brown (10YR 3/2.5) light silty clay loam; weak, fine, subangular blocky structure; clay films along root channels; friable when moist; gradual boundary.

B_2 24 to 35 inches, mixed light olive-brown (2.5Y 5/4) and dark grayish-brown (2.5Y 4/2) light clay loam; massive; few, medium, distinct, dark-gray (10YR 4/1) mottles; some iron mottles; slightly acid; friable when moist; gradual boundary.

B_3 35 to 44 inches, mixed grayish-brown (2.5Y 5/3) and light olive-brown (2.5Y 5/4) light clay loam; massive; few, medium, distinct, very dark gray to dark gray (10YR 3.5/1) and few, fine, distinct, strong-brown (7.5YR 5/8) mottles; slightly acid; friable when moist; clear boundary.

C_1 44 to 60 inches, mixed light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/3) sandy loam; massive; common, medium, distinct, strong-brown (7.5YR 5/8) mottles; calcareous; loose when moist.

KATO SERIES

The Kato series consists of imperfectly drained Brunizems that developed from loamy outwash materials. They are on outwash terraces within the Late Wisconsin till plain. They are underlain by an unconforming substratum (D horizon) of sand and gravel. The soils are acid throughout the solum and have moderate permeability. The principal native vegetation was prairie grasses.

Kato loams, deep over sand and gravel.—These soils are underlain by sand and gravel below a depth of 36 inches. The A horizon ranges from 10 to 20 inches in thickness and from heavy loam to light silty clay loam in texture. The B horizon ranges from heavy loam to light clay loam and, in places, to sandy clay loam. The C horizon, 6 to 10 inches thick, is heavy sandy loam to loam in texture. The D horizon contains stratified layers of silt, sand, and gravel.

Kato soils are similar to Nicollet soils, but the Nicollet soils are underlain by glacial till.

Kato loam, deep over sand and gravel (SE¼SE¼ sec. 14, T. 93 N., R. 27 W.):

A_{1p} 0 to 8 inches, black (2.5Y 2/1) loam to light silty clay loam; weak, fine and medium, subangular blocky structure; friable when moist; gradual boundary.

A_{12} 8 to 15 inches, black (10YR 2/1) dark-gray to dark grayish-brown (10YR 4/1.5, dry) light silty clay loam; weak, fine, granular structure; friable when moist; gradual boundary.

B_1 15 to 20 inches, dark grayish-brown (2.5Y 4/2) light silty clay loam; weak, very fine, subangular blocky structure; few, fine, faint, very dark gray (10YR 3/1) mottles; slightly firm when moist; gradual boundary.

B_{21} 20 to 26 inches, mixed dark grayish-brown (2.5Y 4/2) and very dark grayish-brown (2.5Y 3/2) silty clay loam; moderate, fine and medium, subangular blocky structure; common, fine, faint, very dark gray (10YR 3/1) mottles; slightly firm when moist; gradual boundary.

B_{22} 26 to 32 inches, dark grayish-brown to grayish-brown (2.5Y 4.5/2) silty clay loam; moderate, fine and medium, subangular blocky structure; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; slightly firm when moist; gradual boundary.

B_{23} 32 to 36 inches, grayish-brown (2.5Y 5/2) light clay loam; moderate, fine and medium, subangular blocky structure; many, medium, distinct, yellowish-brown (10YR 5/4) mottles; some iron and manganese concretions of fine shot size; slightly firm when moist; gradual boundary.

B_3 36 to 40 inches, light olive-brown (2.5Y 5/4) sandy clay loam; weak, medium, subangular blocky structure to massive; few, fine, faint, yellowish-brown (10YR 5/6) mottles; friable when moist; gradual boundary.

C_1 40 to 46 inches, grayish-brown (2.5Y 5/2) heavy sandy loam; massive; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; numerous shale fragments; friable when moist; gradual boundary.

D_{11} 46 to 50 inches, grayish-brown (2.5Y 5/2) gravelly sandy loam; massive; very friable when moist; gradual boundary.

D_{12} 50 to 53 inches, mixed grayish-brown (2.5Y 5/2) and dark grayish-brown (2.5Y 4/2) gravelly sandy loam; massive; numerous shale fragments; friable when moist; gradual boundary.

D_{13} 53 to 60 inches, mixed grayish-brown (2.5Y 5/2) and dark grayish-brown (2.5Y 4/2) gravelly sandy clay loam; massive; very friable when moist; gradual boundary.

D_{14} 60 to 65 inches, grayish-brown (2.5Y 5/2) sandy loam; massive; loose when moist.

Kato loams, moderately deep over sand and gravel.—These soils are underlain by sand and gravel below depths of 24 to 30 inches. The A horizon ranges from 9 to 15 inches in thickness and from medium to heavy loam in texture. The texture of the B horizon ranges from a heavy loam to light clay loam or medium sandy clay loam. The D horizon contains stratified layers of silt, sand, and gravel and a great many shale fragments.

Kato loam, moderately deep over sand and gravel, (SE¼NE¼ sec. 15, T. 93 N., R. 27 W.):

A_1 0 to 15 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable when moist.

B_2 15 to 25 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, fine, subangular blocky structure; few, fine, faint, dark-brown (10YR 3/3) and very dark gray (10YR 3/1) mottles; friable when moist.

B_3 25 to 31 inches, very dark grayish-brown (2.5Y 3/2) sandy clay loam; massive; friable when moist.

D_1 31 to 37 inches, light olive-brown (2.5Y 5/4) sand and gravel.

D_2 37 to 50 inches, yellowish-brown (10YR 5/6) coarse sand and gravel; calcareous.

LAKEVILLE SERIES

The Lakeville series consists of excessively drained, moderately dark colored soils that developed from gravelly, calcareous, stratified, glacial drift. These soils are classified as Brunizems, though they have some characteristics of Regosols. They occur as small kames or knobs or in small areas in recessional moraines. They are calcareous within 24 inches of the surface. The permeability is rapid. The principal native vegetation was prairie grasses.

The A horizon varies from 2 to 7 inches in thickness, from dark brown (10YR 4/3) to very dark grayish brown (10YR 3/2) in color, and from gravelly loam to light sandy loam in texture. A faint B horizon can be distinguished in some of the Lakeville soils. The C horizon is dominantly calcareous gravel but ranges from gravel to gravelly loam.

LAMONT SERIES

In the Lamont series are excessively drained Gray-Brown Podzolic soils. They developed from sandy material, most of which was deposited by wind. They occur mainly on the east side of the East Fork Des Moines River. They have moderately rapid permeability. The slopes are convex. The native vegetation was trees.

The A_1 horizon, 3 to 7 inches thick, is a light sandy loam to heavy sandy loam. The A_2 horizon is 5 to 10 inches thick; it is a light to medium fine sandy loam. The B horizon is 10 to 30 inches thick and, in texture, is sandy loam to light sandy clay. The C horizon is loamy sand or sand.

The Lamont soils have a thinner A_1 horizon than the Dickinson soils.

Lamont fine sandy loam (NE¼SE¼ sec. 22, T. 92 N., R. 28 W.):

A_{11} 0 to 2 inches, very dark brown (10YR 2/2) sandy loam; weak, very fine, granular structure; neutral; very friable when moist; clear boundary.

A_{12} 2 to 7 inches, very dark brown (10YR 2/2, moist) sandy loam; weak, fine, granular structure to massive; neutral; friable when moist; clear boundary.

A_{21} 7 to 13 inches, dark grayish-brown (10YR 4/2), grayish-brown (10YR 5/2, dry), light fine sandy loam; weak, thick, platy structure to massive; very friable when moist; strongly acid; clear boundary.

A_{22} 13 to 16 inches, dark grayish-brown (10YR 4/2) fine sandy loam; massive; strongly acid; very friable when moist; clear boundary.

B_1 16 to 20 inches, dark-brown (10YR 3/3 and 4/3), dark-brown (10YR 3/3, dry), heavy sandy loam; moderate, fine to medium, subangular blocky structure; light-gray (10YR 7/2, dry) ped coatings; strongly acid; friable when moist; hard when dry; gradual boundary.

B_2 20 to 30 inches, dark-brown (10YR 3/3) light sandy clay loam; weak, fine to medium, subangular blocky structure; few, discontinuous, very dark grayish-brown (10YR 3/2) clay films; medium acid; friable when moist; hard when dry; gradual boundary.

B_3 30 to 36 inches, dark yellowish-brown (10YR 4/4) sandy loam; massive; some dark-brown (7.5YR 3/3) ped coatings; medium acid; friable when moist; hard when dry; gradual boundary.

C 36 to 50 inches, dark-brown (10YR 4/3) loamy sand; single grain; slightly acid; very friable to loose when moist.

LESTER SERIES

The Lester series consists of well-drained soils that developed from friable, calcareous, loam till of Late Wisconsin age. These soils are classified as Gray-Brown Podzolic soils that intergrade to Brunizems. They occur in the more hilly areas along the major streams. The slopes range from 2 to 50 percent and are concave and convex. The soils are acid throughout the solum and are leached of carbonates to depths of 40 to 60 inches. They are moderately permeable. The native vegetation was mixed grass and trees. Presumably, the trees recently encroached on the prairie.

The A_1 horizon is as much as 9 inches thick in the nearly level areas. It decreases in thickness with increase in gradient. The texture of the A_1 horizon ranges from light to heavy loam. The incipient A_2 horizon is 2 to 5 inches thick. The B horizon ranges from heavy loam to light clay loam.

The Lester soils differ from the Clarion soils in having a weak A_2 horizon, a lighter colored A_1 horizon, and slightly finer textured B horizon.

Lester loam (SW¼NW¼ sec. 13, T. 93 N., R. 28 W.):

A_1 0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, granular structure; friable when moist.

A_2 6 to 9 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, platy breaking to granular structure; friable when moist.

B_1 9 to 14 inches, dark-brown (10YR 3/3) heavy loam; weak, fine to medium, subangular blocky structure; friable when moist.

B_2 14 to 27 inches, dark-brown (10YR 4/3) light clay loam; weak, medium, subangular blocky structure; slightly firm when moist.

B_3 27 to 35 inches, dark yellowish-brown (10YR 4/4) heavy loam; weak, medium, subangular blocky structure to massive; friable when moist.

C_1 35 to 72 inches, yellowish-brown (10YR 5/6) loam; massive; friable when moist.

C_2 72 inches+, light yellowish-brown (10YR 6/4) loam; massive; calcareous; friable when moist.

LESUEUR SERIES

The LeSueur series consists of imperfectly drained soils that developed from friable, calcareous, loam till of Late Wisconsin age. These soils are classified as Gray-Brown Podzolic soils that intergrade to Brunizems. They are on uplands near the more strongly dissected areas along the major streams. They are moderately to moderately slowly permeable and are acid throughout the solum. The slopes are concave and convex and range from 1 to 3 percent. The native vegetation was mixed grass and trees. Presumably, the trees recently encroached on the prairie.

The A_1 horizon varies from 6 to 11 inches in thickness, from heavy loam to light silty clay loam in texture, and from black (10YR 2/1) to very dark gray (2.5Y 3/0) in color. The A_2 horizon, 2 to 5 inches thick, ranges from silt loam to loam. The texture of the B_2 horizon ranges from light to medium clay loam.

The LeSueur soils differ from the Nicollet soils in having a thinner A_1 horizon, a weak A_2 horizon, and a finer textured B horizon.

LeSueur loam (SW¼NE¼ sec. 18, T. 93 N., R. 30 W.):

A_1 0 to 6 inches, black (10YR 2/1) heavy loam; moderate, medium, granular structure; friable when moist; slightly acid; gradual boundary.

A_2 6 to 10 inches, very dark gray (10YR 3/1) silt loam; gray 10YR 5/1, dry) coatings; weak, thin, platy and weak, fine, subangular blocky structure; slightly acid; friable when moist; gradual boundary.

B_1 10 to 19 inches, mixed very dark gray (10YR 3/1) and dark grayish-brown (2.5Y 4/2) silt loam; weak, fine, subangular blocky structure; slightly acid; slightly firm when moist; gradual boundary.

B_2 19 to 25 inches, mixed very dark grayish-brown (10YR 3/2) and dark grayish-brown (2.5Y 4/2) clay loam; moderate, fine, subangular blocky structure; few, medium, distinct, dark-brown (7.5YR 4/4, moist) mottles; slightly acid; firm when moist; gradual boundary.

B_3 25 to 34 inches, mixed dark grayish-brown (10YR 4/2) and (2.5Y 4/2) light clay loam; weak, medium, subangular blocky structure; few, medium, distinct, strong-brown (7.5YR 5/6) mottles; slightly acid; slightly firm when moist; gradual boundary.

C_1 34 to 50 inches, mixed grayish-brown (2.5Y 5/2) and dark grayish-brown (2.5Y 4/2) loam; massive; neutral; friable when moist.

MARSHAN SERIES

The Marshan series consists of poorly drained soils that developed from medium textured to moderately fine textured outwash materials of Late Wisconsin age. These soils are on terraces or along minor upland streams. They are classified as Wiesenbodens. They are underlain by an unconforming substratum (D horizon) of sand and gravel. Their permeability is moderately slow. The slope range is 0 to 2 percent. In the solum, most of these soils are nearly neutral, but some are alkaline. The native vegetation was swamp grasses and sedges.

Marshan silty clay loams, deep over sand and gravel.—These soils are underlain by sand and gravel below a depth of 36 inches. The A horizon is 12 to 20 inches thick and ranges in texture from light silty clay loam to heavy silty clay loam. This layer is black (10YR 2/1, 2.5Y 2/0, or 5Y 2/1). The B_g horizon ranges from medium silty clay loam or clay loam to heavy silty clay loam. In areas where there is a C_g horizon, it ranges from loam to light silty clay loam. The D horizon contains stratified layers of fine, medium, and coarse gravel, shaly gravel, and sand.

Except for the unconforming substratum, these soils resemble the Webster soils. They have a darker and thicker A horizon than the Kato soils.

Marshan silty clay loam, deep over sand and gravel (250 yards north and 30 yards east of SW¼SE¼ sec. 13, T. 92 N., R. 27 W.):

A_{1p} 0 to 7 inches, black (2.5Y 2/0) silty clay loam; weak, fine, granular structure; friable when moist; gradual boundary.

A_{12} 7 to 11 inches, black (2.5Y 2/0) medium silty clay loam; moderate, fine, granular structure; friable when moist; gradual boundary.

A_{13} 11 to 16 inches, black (2.5Y 2/0) medium silty clay loam; moderate, very fine, subangular blocky structure; slightly firm when moist; gradual boundary.

B_{g1} 16 to 20 inches, black (5Y 2/2) medium clay loam; moderate, very fine, subangular blocky structure; common, medium, faint, very dark gray (5Y 3/1) mottles; firm when moist; gradual boundary.

B_{g21} 20 to 25 inches, olive-gray (5Y 4/2), very dark gray 5Y 3/1) when crushed, silty clay loam; moderate, very fine, subangular blocky structure; common, medium, faint, very dark gray (5Y 3/1) and olive-gray (5Y 5/2) mottles; slightly firm when moist; clear boundary.

B_{g22} 25 to 30 inches, olive-gray (5Y 4/2), olive-gray (5Y 4.5/2) when crushed, silty clay loam; weak to moderate, very fine, subangular blocky structure; few, fine, faint, very dark gray (5Y 3/1) and few, fine, distinct, brown (7.5YR 5/4) mottles; slightly firm when moist; gradual boundary.

B_{g3} 30 to 40 inches, olive-gray (5Y 5/2) clay loam; weak, very fine, subangular blocky structure; few, medium, faint, olive-gray (5Y 4/2) and few, fine, distinct, yellowish-brown (10YR 5/8) mottles; slightly firm when moist; gradual boundary.

D_1 40 to 47 inches, fine and medium gravel and shale fragments; some shale fragments coated with iron and manganese.

D_2 47 to 54 inches, fine, medium, and coarse, calcareous gravel containing shale fragments, some of which are coated with iron and manganese.

Marshan silty clay loams, moderately deep over sand and gravel.—These soils are underlain by sand and gravel at depths of 24 to 30 inches. The A horizon ranges from 10 to 15 inches in thickness and from light silty clay loam to medium clay loam in texture. This layer is black (10YR 2/1, 2.5Y 2/0, or 5Y 2/1). The texture of the B_g horizon ranges from medium clay loam to medium silty clay loam. The C horizon is 3 to 6 inches thick and ranges from medium loam to heavy loam. The D horizon is stratified fine, medium, and coarse gravel, shaly gravel, and sand.

Marshan silty clay loam, moderately deep over sand and gravel:

A_{1p} 0 to 6 inches, black (2.5Y 2/0, moist) silty clay loam; moderate, very fine, subangular blocky structure; friable when moist.

A_{12} 6 to 12 inches, black (2.5Y 2/1, moist) silty clay loam; moderate, very fine, subangular blocky structure; slightly firm when moist.

B_{g1} 12 to 16 inches, very dark grayish-brown (2.5Y 3/2, moist) silty clay loam; moderate, very fine, subangular blocky structure; common, medium, faint, very dark gray (2.5Y 3/1, moist) mottles; slightly firm when moist.

B_{g2} 16 to 25 inches, mixed dark grayish-brown (2.5Y 4/2, moist) and olive (5Y 5/3, moist) silty clay loam; weak to moderate, fine, subangular blocky structure; common, medium, faint, very dark gray (5Y 3/1, moist) mottles; slightly firm when moist.

C_{g1} 25 to 28 inches, grayish-brown (2.5Y 5/2, moist) heavy loam; massive; many, medium, prominent, strong-brown (7.5YR 5/6, moist) mottles; friable when moist.

D 28 to 40 inches, fine, medium, and coarse gravel containing shale and sand in stratified layers.

MUCK

Muck is very poorly drained organic material overlying stratified, calcareous, glacial drift. It is classified as a Bog soil. The areas are in old lakebeds on the Late Wisconsin till plain and generally are surrounded, or rimmed, by Harpster soils. The organic material ranges from extremely acid to alkaline. The native vegetation was swamp grasses and sedges.

A thin horizon of dark-colored mineral soil commonly lies between the muck surface layer and the underlying gleyed, stratified sand and silt. In short distances within an area, the thickness of the muck layer varies widely. Two phases of Muck were mapped. Muck, moderately shallow, is 25 to 60 inches deep. Muck, shallow, is 10 to 25 inches deep.

Muck, shallow (100 yards west and 35 yards south of NW corner of NE¼NW¼ sec. 33, T. 92 N., R. 27 W., Lake Township):

1 0 to 7 inches, black (10YR 2/1) fibrous, peaty muck; loose when moist.

2 7 to 11 inches, black (10YR 2/1) to very dark gray (10YR 3/1), peaty muck containing brown fibers; weak, thin, platy structure; loose when moist.

3 11 to 17 inches, black (10YR 2/1) to very dark gray (10YR 3/1) muck containing fine fibers; moderate, thin, platy structure; loose when moist.

4 17 to 22 inches, black (2.5Y 2/0) to very dark gray (2.5Y 3/0) mucky silt loam; moderate, thin, platy structure; strong-brown (7.5YR 5/8) root channels; very friable when moist.

5 22 to 30 inches, black (2.5Y 2/0) to very dark gray (2.5Y 3/0) mucky silt loam; weak, very fine, subangular blocky structure; red (2.5YR 4/8) and strong-brown (7.5YR 5/8) root channels; friable when moist.

6 30 to 35 inches, light olive-gray (5Y 6/2) to olive-gray (5Y 5/2) silt loam; massive; many, coarse, prominent, strong-brown (7.5YR 5/8) and yellowish-brown (10YR 5/6, moist) mottles; very friable when moist.

MUCKY PEAT

Mucky peat is very poorly drained, fibrous, organic material, over stratified, calcareous, glacial drift. It is in the Bog great soil group. The areas are old lakebeds on the Lake Wisconsin till plain and are practically everywhere surrounded by Harpster soils. The reaction ranges from acid to alkaline. A layer of brown, raw, fibrous peat, 2 to 10 inches thick, is common below a depth of 6 inches. Generally, there is a dark-colored horizon of mucky silt loam just above the calcareous, gleyed, and stratified sand and silt. Three phases of Mucky peat were mapped. Mucky peat, shallow, is 10 to 25 inches deep. Mucky peat, moderately shallow, is 25 to 40 inches deep. Mucky peat, deep, is 40 to 60 inches deep.

Mucky peat, moderately shallow (75 yards south and 10 yards east of the NW corner of NW¼NW¼ sec. 12, T. 92 N., R. 27 W., Vernon Township):

1 0 to 4 inches, black (10YR 2/1) peaty muck; loose when moist.

2 4 to 10 inches, black (10YR 2/1), very dark brown (10YR 2/2) when crushed, fibrous peat; loose when wet.

3 10 to 15 inches, black (10YR 2/1), very dark brown (10YR 2/2) when crushed, fibrous peat; moderate, very thin, platy structure; loose when moist.

4 15 to 21 inches, black (10YR 2/1), very dark brown (10YR 2/2) when crushed, peat; moderate, very thin, platy structure; strong-brown (7.5YR 5/6, 5/8) root channels; loose when moist.

5 21 to 28 inches, black (5Y 2/1), very dark brown (10YR 2/2) when crushed, peaty muck; massive; many, strong-brown (7.5YR 5/6, 5/8, moist) root channels; very friable when moist.

6 28 to 36 inches, black (5Y 2/1) to very dark gray (5Y 3/1), dark-brown (7.5YR 3/2) when crushed, mucky silt loam; massive; reddish-brown (5YR 5/4) and yellowish-red (5YR 4/6, moist) root channels; very friable when moist.

7 36 to 44 inches, dark-gray (5Y 4/1) mucky silt loam; massive; reddish-brown (5YR 5/4) and yellowish-red (5YR 4/6) root channels; very friable when moist.

8 44 to 52 inches, mixed gray (5Y 5/1) and dark-gray (5Y 4/1) light silty clay loam; massive; few, medium, prominent olive (5Y 5/4 and 5Y 5/6) mottles; reddish brown 5YR 4/4) and yellowish red (5YR 4/6) in root channels; calcareous; very friable when moist.

9 52 to 62 inches, mixed gray (5Y 6/1, moist) and light-gray (5Y 7/2) light silty clay loam; massive; many, coarse, distinct, olive (5Y 5/4, 5/6) mottles; reddish-brown (5YR 4/4) and yellowish-red (5YR 4/6) root channels; calcareous; friable when moist.

NICOLLET SERIES

The Nicollet soils are Brunizems that developed under prairie grasses in the uplands. The parent material is friable, calcareous, Late Wisconsin glacial till of loam texture. The slopes are dominantly convex, but some are concave. The slope range is about 1 to 3 percent. Nicollet soils are imperfectly drained and moderately permeable.

The A_1 horizon is 9 to 16 inches thick. It ranges from loam to light clay loam in texture and from black (10YR 2/1) to very dark brown (10YR 2/2) or very dark gray (10YR 3/1) in color. The texture of the B horizon ranges from heavy loam to light clay loam and is about 3 percent higher in clay content than the A horizon. Generally, the depth to carbonates is about 35 to 40 inches.

The Nicollet soils are not so well drained as the Clarion soils and are not so poorly drained as the Webster soils.

Nicollet loam (NE¼NE¼ sec. 34, T. 93 N., R. 28 W.):

A_1 0 to 9 inches, very dark gray (10YR 3/1) heavy loam; moderate, fine, granular structure; friable when moist.

A_3 9 to 14 inches, very dark gray (10YR 3/1, moist) heavy loam; moderate, medium, granular structure; friable when moist.

B_1 14 to 26 inches, mixed very dark grayish-brown (10YR 3/2) and very dark brown (10YR 2/2, moist) light clay loam; moderate, fine, subangular blocky structure; slightly firm when moist.

B_3 26 to 31 inches, mixed dark grayish-brown (10YR 4/2) and very dark grayish-brown (10YR 3/2 to 2.5Y 3/2) light clay loam; weak, fine, subangular blocky structure; slightly firm when moist.

C_1 31 to 41 inches, mixed dark grayish-brown (2.5Y 4/2 and very dark grayish-brown (2.5Y 3/2) light clay loam; massive; few, fine, distinct, dark-brown (7.5YR 4/2) mottles; slightly firm when moist.

C_2 41 inches+, mixed dark grayish-brown (2.5Y 4/2) and very dark grayish-brown (2.5Y 3/2) loam; massive; few, fine, distinct, dark-brown (7.5YR 4/2) mottles; calcareous; friable when moist.

OKOBOJI SERIES

The Okoboji series consists of Wiesenbodens that intergrade to Alluvial soils. These soils are very poorly drained and have moderate to moderately slow permeability. They developed from local alluvium or reworked glacial material. They are in large and small depressions, or potholes, in the uplands and are surrounded, or rimmed, by Harpster soils. The relief of the surrounding areas is nearly level to rolling. Generally, the areas of Okoboji soils are larger than those of the Glencoe or Rolfe soils, which also occur in depressions. The surface horizon of the Okoboji soils is neutral or slightly calcareous. The native vegetation was swamp grasses and sedges.

The A horizons vary from 15 to 25 inches in thickness, from mucky silt loam to light silty clay loam in texture, and from black (5Y 2/1) to very dark gray (5Y 3/1) in color. The B_g horizons range from light to heavy silty clay loam. They are generally 3 to 7 percent higher in content of clay than the A horizons.

Okoboji silt loam has a thicker A_1 horizon than the Webster or Wacousta soils. Laboratory data for the following profile of Okoboji silt loam is presented in table 6, p. 47.

Okoboji silt loam (180 yards west and 30 yards south of the NE corner of NW¼NW¼ sec. 5, T. 93 N., R. 27 W., Vernon Township):

A_{1p} 0 to 5 inches, very dark gray (10YR 3/1, moist) silt loam; weak, medium, granular structure; very friable when moist.

A_{12} 5 to 10 inches, very dark gray (10YR 3/1, moist) silt loam; weak, medium, granular structure; very friable when moist.

A_{13} 10 to 16 inches, black (10YR 2/1, moist) heavy silt loam; moderate, thin, platy structure; friable when moist.

B_{21g} 16 to 21 inches, black (10YR 2/1, moist) silty clay loam; weak, very fine, subangular blocky structure; friable when moist.

B_{22g} 21 to 26 inches, black (5Y 2/1, moist) heavy silty clay loam; moderate, fine, subangular blocky structure; slightly firm when moist.

B_{3g} 26 to 30 inches, black (5Y 2/1, 2/2, moist) silty clay loam; weak, coarse, subangular blocky structure; dark-brown (7.5YR 4/4, moist) root channels; slightly firm when moist.

C_{g1} 30 to 34 inches, gray (5Y 5/1, moist) to dark-gray (5Y 4/1, moist) and very dark gray (5Y 3/1, moist) silty clay loam; massive; dark-brown (7.5YR 4/4, moist) root channels; slightly firm when moist.

C_{g2} 34 to 42 inches, gray (5Y 5/1, moist) to olive (5Y 5/3, moist) silt loam; massive; yellowish-red (5YR 4/6, moist) iron concretions that are 1½ inches in diameter and appear to run in horizontal veins; calcareous; friable when moist.

C_{g22} 42 to 49 inches, gray (5Y 5/1, moist) to olive (5Y 5/4, 5/6, moist) silt loam; massive; common, fine, distinct, light olive-brown (2.5Y 5/6, moist) mottles; calcareous; friable when moist.

OKOBOJI SERIES, IMPERFECTLY DRAINED VARIANT

These are dark-colored soils that developed under grass, in depressions that appear to be sinkholes and are filled with colluvium. The soils are classified as Brunizems that intergrade to Alluvial soils. They occur only in small areas in general soil area 3 in the southwestern part of the county where limestone bedrock is nearer the surface than in the rest of the county. The surface horizon is slightly acid. Permeability is moderate. These soils have concave slopes of 1 to 3 percent. The topographic position is similar to that of the Glencoe soils.

The A_{11} horizon varies from 10 to 25 inches in thickness, from loam to light silty clay loam in texture, and from very dark gray (10YR 3/1) to black (10YR 2/1) in color. The A_{12} horizon is black (10YR 2/1 and 5Y 2/1) and is 15 to 50 inches thick. It varies from silt loam to light silty clay loam. If a B horizon is distinguishable, it varies from silt loam to light silty clay loam.

Okoboji silt loam, imperfectly drained variant (SE¼ SW¼ sec. 2, T. 91 N., R. 30 W.):

A_{11} 0 to 15 inches, very dark gray (10YR 3/1) silt loam; friable when moist.

A_{12} 15 to 30 inches, black (10YR 2/1) silt loam; friable when moist.

B_{11} 30 to 40 inches, dark grayish-brown (10YR 4/2) silt loam; friable when moist.

B_{12} 40 to 45 inches, dark grayish-brown (10YR 4/2) silt loam; friable when moist.

B_2 45 to 50 inches, grayish-brown (10YR 5/2) light clay loam; slightly firm when moist.

ORIO SERIES

The soils of the Orio series are Planosols that developed under swamp grasses and sedges from very friable, glacial outwash or reworked glacial till and outwash materials. These soils are poorly drained and slowly permeable. They are in depressions on the upland till plain, generally near the major streams. Unlike some of the other soils in depressions, these soils are not rimmed by the calcareous Harpster soils.

The A horizons vary in texture from light silt loam to sandy loam. Fine sandy loam predominates. The B_g horizons are sandy clay, sandy clay loam, or medium clay loam. In some places there are two or three B_g horizons, separated by layers of loamy sand. The C horizon is highly stratified glacial drift containing layers of silt, coherent sand, and loam.

The A and B horizons are sandier than those in the Rolfe soils.

Orio fine sandy loam (SE¼SW¼ sec. 5, T. 92 N., R. 30 W.):

A_1 0 to 8 inches, black to very dark gray (10YR 2.5/1) fine sandy loam; weak, fine, granular structure; strongly acid; friable when moist; clear boundary.

A_{21} 8 to 12 inches, very dark gray (10YR 3/1) and gray (10YR 5/1, dry) sandy loam; moderate, thin, platy structure; friable when moist; strongly acid; gradual boundary.

A_{22} 12 to 16 inches, dark-gray (10YR 4/1) and gray (10YR 6/1, dry) sandy loam; weak, medium, platy structure; medium acid; friable when moist; clear boundary.

$A_{23}B_1$ 16 to 20 inches, very dark gray to dark gray (10YR 3.5/1) or gray (10YR 6/1, dry) light loam; weak, medium, platy structure; slightly firm when moist; medium acid; clear boundary.

A_{g21} 20 to 26 inches, mixed very dark gray to dark-gray (10YR 3.5/1) and very dark grayish-brown (10YR 3/2) sandy clay loam; dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) coatings; weak, medium, subangular blocky structure; slightly acid; hard when dry; firm when moist; gradual boundary.

B_{g22} 26 to 37 inches, gray (5Y 5/1) heavy sandy clay loam intermixed with layers of sandy loam; weak, medium, blocky structure to massive; few, fine, distinct, light-gray (5Y 7/1) and white (5Y 8/1) mottles; slightly acid; firm to friable when moist; gradual boundary.

B_{g3} 37 to 45 inches, mixed dark-gray (5Y 4/1) and gray (5Y 5/1) light sandy clay loam; weak, medium, blocky structure; common, fine, distinct, dark-brown (7.5YR 3/4) mottles; hard when dry; slightly acid; slightly firm when moist; gradual to diffuse boundary.

C_g 45 to 60 inches, dark-gray (10YR 4/1) sandy loam; massive; slightly acid; hard when dry.

PLATTVILLE SERIES

The soils of the Plattville series are imperfectly drained, moderately permeable Brunizems. Those in Humboldt County intergrade to Alluvial soils. These soils developed under grass from loamy alluvial material, including glacial outwash. They are underlain by limestone bedrock at depths of 3 to 5 feet. Areas of these soils are adjacent to small upland drainageways and on nearly level benches adjacent to major streams within the Late Wisconsin till plain.

The A horizons are dominantly loam but in some areas are gritty silt loam. The B horizon ranges from light clay loam to heavy loam. The D horizon generally has a 2- to 4-inch layer of decomposed limestone and limestone fragments over unweathered bedrock.

The Plattville soils are the imperfectly drained analogs of the Copas soils. The Plattville soils have thicker and darker A_1 horizons and poorer natural drainage than the Copas soils. In Humboldt County, they are deeper to bedrock.

Plattville loam (NE¼NE¼ sec. 11, T. 91 N., R. 30 W.):

A_1 0 to 10 inches, black (10YR 2/1) loam; weak, fine, granular structure; medium acid; friable when moist; gradual boundary.

A_{12} 10 to 15 inches, mixed black (10YR 2/1) and very dark gray (10YR 3/1) loam; weak, granular structure; medium acid; friable when moist; gradual boundary.

B_1 15 to 24 inches, very dark grayish-brown (2.5Y 3/2) light clay loam; very weak, fine, subangular blocky structure; slightly acid; friable when moist; gradual boundary.

B_{22} 24 to 30 inches, dark grayish-brown (2.5Y 4/2) light clay loam; weak, fine, subangular blocky structure; slightly acid; slightly firm when moist; gradual boundary.

B_{23} 30 to 42 inches, dark grayish-brown (10YR 4/2) heavy loam; very weak, fine, subangular blocky structure; neutral; friable when moist; gradual boundary.

B_3 42 to 48 inches, brown (10YR 5/3) loam; massive; common, fine, prominent, strong-brown (7.5YR 5/8) mottles; neutral; friable when moist; abrupt boundary.

D 48 inches+, brownish-yellow (10YR 6/6) decomposed limestone and limestone fragments in a layer 2 inches thick over limestone.

ROLFE SERIES

In the Rolfe series are very poorly drained soils that developed under swamp grasses and sedges from calcareous glacial drift of Late Wisconsin age. They are classified as Planosols. They are found throughout the county, in potholes or other depressions on the upland till plain. Unlike some other soils in similar positions, they are not rimmed, or surrounded, by the Harpster soils. The Rolfe soils are very poorly drained, slowly to very slowly permeable, and acid throughout the solum.

The A_1 horizon ranges from 4 to 9 inches in thickness, from medium to heavy silt loam in texture, and from black (10YR 2/1) to very dark gray (10YR 3/1) in color. The A_2 horizon ranges from 6 to 14 inches in thickness, from light loam to light silt loam in texture, and from dark gray (10YR 4/1) to light brownish gray (10YR 6/2) in color. The B_g horizon ranges from 30 to 45 inches in thickness, from heavy clay loam to light clay in texture, and from mottled grayish brown (2.5Y 5/2) to mottled olive gray (5Y 5/2) in color. In this horizon, continuous clay films are around the peds and along the vertical cleavage planes. The C_g horizon of very friable glacial drift has highly stratified layers of silt, coherent sand, and loam. Generally, it is calcareous below a depth of 60 inches.

The Rolfe soils contain more organic matter than the Ames soils. They have darker colored A_1 and B_g horizons.

Laboratory data for the following profile of Rolfe silt loam are presented in table 6, p. 47.

Rolfe silt loam (110 yards west and 8 yards north of the SE corner of SE¼SW¼ sec. 1, T. 92 N., R. 29 W., Rutland Township):

A_p 0 to 9 inches, black (10YR 2/1) to very dark gray (10YR 3/1) silt loam; weak, coarse, granular structure; friable when moist.

A_2 9 to 16 inches, dark-gray (10YR 4/1) to gray (10YR 6/1) silt loam; strong, very thin, platy structure; few, fine, prominent, yellowish-red (5YR 5/8) mottles; friable when moist.

A_3B_{g1} 16 to 20 inches, very dark gray (10YR 3/1) silt loam; weak to moderate, medium, subangular blocky structure to weak, very thin, compound, platy structure; gray (10YR 6/1) coatings; friable when moist.

B_{g21} 20 to 26 inches, olive-gray (5Y 4/2 to 5/2) gritty silty clay; strong, very fine, subangular blocky structure; few, fine, prominent, yellowish-red (5YR 5/8) iron mottles; clayskins present; very firm when moist.

B_{g22} 26 to 29 inches, olive-gray (5Y 4/2 to 5/2) heavy silty clay loam; moderate, medium, subangular blocky structure; common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; clayskins present; very firm when moist.

B_{g23} 29 to 36 inches, olive-gray (5Y 5/2) clay; moderate, medium, subangular blocky structure; common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; black (5Y 2/1) material in root channels and crayfish holes; clayskins present; very firm when moist.

B_{g31} 36 to 41 inches, olive-gray (5Y 5/2, 5/4) light clay loam; massive with some vertical cleavage planes; common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; black (5Y 2/1) material in root channels and crayfish holes; clayskins present; firm when moist.

B_{g32} 41 to 48 inches, olive-gray (5Y 5/2 and 4/2) light clay loam; massive; few to common, fine, distinct, yellowish-red (5YR 5/8) iron mottles; black (5Y 2/1) material in root channels and crayfish holes; slightly firm when moist.

C_{g1} 48 to 55 inches, olive-gray (5Y 5/2) loam; massive; few, fine, distinct, very dark gray (5Y 3/1) and light olive-brown (2.5Y 5/6) mottles; friable when moist.

C_{g2} 55 to 62 inches, olive-gray (5Y 5/2) loam; massive; few, fine, distinct, very dark gray (5Y 3/1, moist) mottles and common, coarse, prominent, yellowish-red (5YR 5/8) iron mottles; calcareous; very friable.

SOGN SERIES

In the Sogn series are well-drained soils that are underlain by limestone bedrock at depths of 10 to 15 inches. They are classified as Lithosols.

Sogn loam:

A 0 to 10 inches, black (10YR 2/1) loam to silt loam; weak, fine and very fine, granular structure; friable; the uppermost 5 inches contains sand-sized calcareous fragments, but the matrix is not calcareous; below a depth of 5 inches, limestone fragments 3 to 5 inches across are abundant.

D 10 inches+, limestone bedrock.

STORDEN SERIES

The soils of the Storden series are Regosols that developed in the uplands from friable, calcareous loam till of Late Wisconsin age. They are well drained to excessively drained and are moderately permeable. The slope range is 9 to 50 percent. The principal native vegetation was prairie grasses.

The A horizon, where present, ranges up to 8 inches in thickness. It ranges in color from very dark grayish brown (10YR 3/2) to dark yellowish brown (10YR 4/4). It is thinner and lighter colored than the A horizon in the Clarion soils. The Storden soils are calcareous at or within 12 inches of the surface. They contrast with Clarion soils in not having a B horizon.

Storden loam (NE¼NW¼ sec. 11, T. 92 N., R. 28 W.):

A_1 0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; weak, medium, granular structure; carbonates at 3 to 4 inches; friable when moist.

A_3C_1 6 to 10 inches, mixed very dark grayish-brown (10YR 3/2) and dark-brown (10YR 4/3) loam; massive; calcareous; friable when moist.

C_2 10 inches+, yellowish-brown (10YR 5/4) loam; massive; calcareous; friable when moist.

TERRIL SERIES

The soils of the Terril series developed from local alluvium. They are moderately well drained and moderately permeable. These soils are classified as Brunizems that intergrade to Alluvial soils. They have concave slopes that range from 0 to 9 percent. They are in the uplands, at the base of stronger slopes, and between the uplands and the stream terraces, at the base of sharp slopes. The principal native vegetation was prairie grasses.

The A horizon is 15 to 30 inches thick. It is medium to heavy loam and is very dark gray (10YR 3/1) to very dark brown (10YR 2/2). In some areas where alluvial material has recently been deposited, the surface layer is very dark grayish brown (10YR 3/2). In some places the B horizon is not distinguishable; where it can be seen, it ranges from very dark grayish brown (10YR 3/2) to dark brown (10YR 4/3). The C horizon is dark grayish brown (10YR 4/2) to brown (10YR 5/3).

The Terril soils have a thicker A horizon than the Nicollet soils and are finer textured and darker colored than the Ankeny soils.

Terril loam (NE¼NW¼ sec. 31, T. 92 N., R. 30 W.):

A 0 to 24 inches, very dark gray (10YR 3/1) loam; weak, medium, granular structure; friable when moist.

B 24 to 40 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable when moist.

C 40 to 50 inches, dark grayish-brown (10YR 4/2) to grayish-brown (10YR 5/2) loam; massive; friable when moist.

TRUMAN SERIES

The soils of the Truman series are Brunizems that developed from silty alluvium. They are on Late Wisconsin outwash terraces where slopes range up to 20 percent. The soils are well drained and moderately permeable. Calcium carbonates are at depths of 36 to 60 inches. The principal native vegetation was prairie grasses.

The A horizon is 10 to 17 inches thick where it is not eroded. It is black (10YR 2/1) to very dark gray (10YR 3/1) in the nearly level areas. This horizon becomes lighter colored and thinner as the slope increases. The B horizon is 15 to 35 inches thick. It ranges from light silt loam to heavy silt loam in texture and from yellowish brown (10YR 4/4, 5/4) to olive brown (2.5Y 4/4) in color. The C horizon ranges from silt loam to light silty clay loam and, in some places, contains thin lenses of very fine sand. Normally, sand and gravel are at depths of 7 to 10 feet.

Truman silt loam:

A_{1p} 0 to 8 inches, very dark gray (10YR 3/1) silt loam; weak, fine, granular structure; slightly acid; friable when moist; gradual boundary.

A_{12} 8 to 13 inches, very dark gray (10YR 3/1) silt loam; weak, medium, platy structure and weak, fine, subangular blocky structure; slightly acid; friable when moist; gradual boundary.

A_3 13 to 17 inches, very dark brown (10YR 2/2) and very dark gray (10YR 3/1) silt loam; weak, fine, granular structure; slightly acid; friable when moist; gradual boundary.

B_1 17 to 24 inches, very dark brown (10YR 2/2) silt loam; weak, fine, subangular blocky structure; few, fine, distinct, dark yellowish-brown (10YR 4/4) and common, fine, faint, dark-brown (10YR 3/3, moist) mottles; medium acid; friable when moist; gradual boundary.

B_2 24 to 32 inches, yellowish-brown (10YR 5/4) silt loam; weak, fine, subangular blocky structure; few, fine, distinct, very dark brown (10YR 2/2) and common, medium, faint, dark-brown (10YR 3/3) mottles; slightly acid; friable when moist; clear boundary.

B_3 32 to 46 inches, yellowish-brown (10YR 5/4) silt loam; massive; friable when moist; neutral; gradual boundary.

C_{11} 46 to 52 inches, mixed grayish-brown (2.5Y 5/2) and olive-brown (2.5Y 4/4) silt loam; massive; many, fine, distinct, reddish-brown (5YR 4/4) mottles; calcareous; friable when moist; gradual boundary.

C_{12} 52 to 84 inches, gray (5Y 6/1) silt loam; massive; calcareous; friable when moist; clear boundary.

D 84 to 100 inches, coarse sand and gravel; loose when moist.

WABASH SERIES

The soils of the Wabash series developed in fine-textured alluvium on level to slightly depressed bottom lands along the major streams. These soils are very poorly drained and are very slowly permeable. They are classified as Wiesenbodens. They are acid throughout the solum. Swamp grasses and sedges have been the native vegetation.

The A horizon, 20 to 35 inches thick, varies in texture from light to heavy silty clay. It is black (10YR 2/1 to 5Y 2/1). The AC transitional zone ranges from 20 to 35 inches in thickness, from light to medium silty clay in texture, and from very dark gray (5Y 2.5/1) to dark gray (5Y 4/1) in color. The material below the AC transition is dark-gray (5Y 4/1) silty clay loam.

The Wabash soils are finer textured and more poorly drained than the Colo soils. In color and texture they are similar to the Glencoe soils, but they have developed from different parent material and in a different topographic position.

Wabash silty clay (SW¼SW¼ sec. 5, T. 93 N., R. 28 W.):

A_{1p} 0 to 6 inches, black (10YR 2/1) light silty clay; firm when moist; diffuse boundary.

A_{12} 6 to 9 inches, black (10YR 2/0.5) medium silty clay; weak to moderate, medium, subangular blocky structure; firm when moist; diffuse boundary.

A_{13} 9 to 12 inches, black (N 2/0) light silty clay; weak to moderate, very fine, subangular blocky structure; very firm when moist; diffuse boundary.

A_{14} 12 to 17 inches, black (N 2/0) light to medium silty clay; weak to moderate, very fine, subangular blocky structure; very firm when moist; diffuse boundary.

A_{14} 17 to 25 inches, black (N 2/0) heavy silty clay; weak, fine and very fine, subangular blocky structure; very firm when moist; diffuse boundary.

AC_1 25 to 32 inches, very dark gray (5Y 2.5/1) medium silty clay; massive; very firm when moist; diffuse boundary.

AC_2 32 to 40 inches, very dark gray (5Y 2.5/1) light to medium silty clay; massive; few, fine, faint, dark-brown (7.5YR 3/4) mottles; very firm when moist; diffuse boundary.

AC_3 40 to 50 inches, very dark gray (5Y 3/1) light silty clay; massive; few, fine, faint, dark-gray (5Y 4/1) mottles; few iron and manganese concretions; very firm when moist.

WACOUSTA SERIES

The Wacousta series consists of nearly level soils that developed from local alluvium and reworked glacial till or outwash. These soils are very poorly drained and are moderately permeable. They are classified as Wiesenbodens. They occur in the larger depressions, which are surrounded, or rimmed, by Harpster soils. The surface horizons are neutral or slightly calcareous. The parent material is calcareous. Swamp grasses and sedges have been the native vegetation.

The black (10YR 2/1 to 5Y 2/1) A_1 horizon, 6 to 10 inches thick, varies from heavy silt loam to light silty clay loam. Silt loam predominates. The B horizon ranges in thickness from 10 to 14 inches, in texture from medium to heavy silty clay loam, and in color from dark olive gray (5Y 3/2) or dark gray (5Y 4/1) to mottled light olive gray (5Y 6/2). The C horizon is mainly stratified glacial drift composed mostly of silt loam and very small amounts of fine sand.

The Wacousta soils have a thinner A horizon and a thinner solum than the Okoboji soils.

Laboratory analyses of the following profile of Wacousta silt loam are presented in table 6, p. 47.

Wacousta silt loam:

A_p 0 to 8 inches, black (2.5Y 2/0) silt loam; weak, medium, granular structure; friable when moist.

A_3B_1 8 to 12 inches, black to dark olive-gray (5Y 2/1 to 3/2) light silty clay loam; weak, very fine, subangular blocky structure; slightly firm when moist.

B_{g2} 12 to 20 inches, dark olive-gray to dark gray (5Y 3/2 to 4/1) and olive-gray (5Y 5/2) heavy silty clay loam; massive; common, coarse, prominent, yellowish-brown (10YR 5/6) iron mottles; firm when moist.

C_{g1} 20 to 26 inches, light olive-gray to olive-gray (5Y 6/2 to 5/2) light silty clay loam; massive; common, coarse, prominent, yellowish-brown (10YR 5/6) iron mottles; dark olive-gray (5Y 3/2) root channels; some small iron and manganese concretions; calcareous; friable when moist.

C_{g2} 26 to 33 inches, light olive-gray to olive-gray (5Y 6/2 to 5/2) silt loam; massive; common, medium, distinct, yellowish-brown (10YR 5/6) iron mottles; some small iron and manganese concretions; calcareous; friable when moist.

WAUKEGAN SERIES

The soils of the Waukegan series are Brunizems. They are well drained to somewhat excessively drained soils that developed from loamy alluvium over sand and gravel on glacial outwash terraces along streams. They are acid throughout the solum. The principal native vegetation was prairie grasses. The Waukegan soils are better drained than the Kato soils.

Four phases of Waukegan loam, moderately deep over sand and gravel, were mapped, and three phases of Waukegan loam, deep over sand and gravel.

Waukegan loams, deep over sand and gravel.—These soils are underlain by sand and gravel at some depth below 36 inches. They are well drained and moderately permeable. The slopes range from 0 to 9 percent. The A horizon, where not eroded, ranges from 9 to 16 inches in thickness, from black (10YR 2/1) to very dark brown (10YR 2/2) in color, and from loam or gritty silt loam to light clay loam in texture. The B horizon is 14 to 20 inches thick. It ranges from loam to light clay loam in the upper part to loam or sandy clay loam in the lower part. It is very dark grayish brown (10YR 3/2) to dark brown (10YR 4/3). The texture of the C horizon ranges from sandy loam to light loam. The D horizon contains fine, medium, and coarse gravel mixed with shale fragments, as well as layers of fine to coarse sand, intermixed with the gravel.

Waukegan loam, deep over sand and gravel (NW¼NE¼ sec. 23, T. 93 N., R. 27 W.):

A_{1p} 0 to 6 inches, black (10YR 2/1) and dark-gray to dark grayish-brown (10YR 4/1.5, dry), gritty, heavy silt loam; weak, fine and medium, granular structure; friable when moist; gradual boundary.

A_{12} 6 to 16 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable when moist; gradual boundary.

B_1 16 to 20 inches, mixed very dark grayish-brown (10YR 3/2) and very dark gray (10YR 3/1) clay loam; moderate, very fine, subangular blocky structure; friable when moist; gradual boundary.

B_2 20 to 25 inches, very dark grayish-brown (10YR 3/2) light clay loam; weak, fine and medium, subangular blocky structure; friable when moist; gradual boundary.
B_3 25 to 30 inches, dark-brown (10YR 3/3) sandy clay loam; weak, medium, subangular blocky structure; some fine gravel; friable when moist; gradual boundary.
C_1 30 to 36 inches, mixed dark-brown (10YR 3/3) and brown (10YR 4/3) sandy loam; massive; some fine gravel; very friable when moist; clear boundary.
D_1 36 to 40 inches, sandy loam containing fine, medium, and coarse gravel; massive; loose when moist.

Waukegan loams, moderately deep over sand and gravel.—These soils are underlain by sand and gravel at depths of 24 to 30 inches. The soils are somewhat excessively drained and have moderately rapid permeability.

The slopes range from 0 to 15 percent. The A_1 horizon ranges from 6 to 10 inches in thickness, from light loam to silt loam in texture, and from very dark gray (10YR 3/1) to very dark grayish brown (10YR 3/2) in color. The B horizon, 10 to 20 inches thick, is dark brown (7.5YR 4/4 to 10YR 3/3). In texture the B horizon ranges from sandy clay loam to loam in the upper part to loam or sandy loam in the lower part. The D horizon consists of fine, medium, and coarse gravel and, in some places, contains layers of fine and coarse sand. The gravel commonly contains many shale fragments. The Waukegan soils are not so sandy in the A and B horizons as the Dickinson soils.

Waukegan loam, moderately deep over sand and gravel (SW¼SE¼ sec. 10, T. 92 N., R. 30 W.):

A_{1p} 0 to 9 inches, very dark gray (10YR 3/1) loam; weak, fine and medium, granular structure; strongly acid; friable when moist; gradual boundary.
A_3 9 to 14 inches, very dark brown (10YR 2/2) loam; moderate, fine and medium, granular structure; many, medium, faint, very dark gray (10YR 3/1) and few, fine, faint, dark-brown (10YR 3/3) mottles; strongly acid; friable when moist; gradual boundary.
B_1 14 to 20 inches, very dark brown (10YR 2/2) light sandy clay loam; weak, fine and medium, subangular blocky structure; few, medium, faint, very dark gray (10YR 3/1) and common, medium, faint, dark-brown (10YR 4/3) mottles; strongly acid; friable when moist; gradual boundary.
B_2 20 to 24 inches, dark-brown (10YR 3/3) loam; moderate, fine and medium, subangular blocky structure; common, medium, distinct, very dark gray (10YR 3/1) mottles; strongly acid; friable when moist; gradual boundary.
B_3 24 to 29 inches, dark-brown (10YR 4/3) sandy loam; massive; strongly acid; friable when moist; gradual boundary.
D_{11} 29 to 34 inches, mixed dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) loamy sand; massive; medium acid; loose when moist; gradual boundary.
D_{12} 34 to 50 inches, light yellowish-brown (10YR 6/4) sand; single grain; medium acid; loose when moist.

WEBSTER SERIES

The soils of the Webster series are Wiesenbodens that developed from glacial till or waterworked glacial material overlying till of Late Wisconsin age. They are in nearly level areas in the uplands. They have poor natural drainage and moderately slow permeability. Except for the calcareous variant, which is calcareous throughout, these soils are slightly acid to neutral in the surface horizons, and their depth to carbonates varies from 24 to 40 inches.

The A horizon, 12 to 25 inches thick, ranges from light clay loam to silty clay loam. It is black (10YR 2/1 or 5Y 2/1) to very dark gray (10YR 3/1). The B horizon, 15 to 30 inches thick, ranges from silty clay loam to clay loam in texture and are normally dark gray (10YR 4/1) to olive gray (5Y 5/2) in color. The C horizon is mottled grayish brown (2.5Y 5/2) to pale olive (5Y 6/3). Generally, it is composed of stratified material containing lenses of silt, coherent sand, or sandy loam. Slightly firm glacial till is normally at depths of 40 to 60 inches. In Humboldt County, probably only a few of the Webster soils developed wholly in glacial till. Webster soils that developed in stratified material are dominant and they are normally in slightly concave positions. Detailed studies of textural variations in similar soils have been made by White (*20*).

The Webster soils differ from the Marshan soils in having predominantly medium textured, stratified parent material over glacial till. The Marshan soils are underlain by coarse-textured, stratified material.

Laboratory data for a representative profile are presented in table 8, p. 48.

Webster silty clay loam that developed in stratified material (Southeast corner of section 29, T. 93 N., R. 27 W.):

A_1 0 to 14 inches, black (10YR 2/1) light silty clay loam to clay loam; moderate, fine granular structure; friable; noncalcareous.
AB_g 14 to 24 inches, black (5Y 2/1 clay loam; weak, medium, subangular blocky structure; friable; noncalcareous; many, coarse, faint, dark-gray (5Y 4/1) mottles.
B_{21g} 24 to 38 inches, olive-gray (5Y 4/2) clay loam; massive; noncalcareous; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles.
CG_1 38 to 42 inches, pale-olive (5Y 6/3 loam; massive; friable; calcareous; many, medium, distinct, light olive-brown (2.5Y 5/6) mottles; a few calcium carbonate concretions; some weak stratification of fine sand and silt loam.
CG_2 42 to 60 inches, light olive-gray (5Y 6/2) loam; massive; calcareous; many, coarse, distinct, light olive-brown (2.5Y 5/6) mottles; some strata of very fine gravel, sand, and silt loam.

Webster silty clay loam that appears to have developed in glacial till (SW¼NW¼ sec. 2, T. 93 N., R. 30 W.):

A_1 0 to 15 inches, black (10Y 2/1) silty clay loam to clay loam; moderate, medium, granular structure; slightly firm when moist.
A_3 15 to 25 inches, very dark gray (10YR 3/1) light clay loam; moderate, medium, granular structure; slightly firm when moist.
B_g 25 to 45 inches, dark-gray (10YR 4/1) light clay loam; moderate, medium, subangular blocky structure; many, medium, faint mottles of very dark gray (10YR 3/1); slightly firm when moist.
C_2 45 to 60 inches, grayish-brown (2.5Y 5/2) loam; massive; many, medium, faint, light brownish-gray (2.5Y 6/2) and few, medium, prominent, dark-brown (7.5YR 4/4) mottles; calcareous; slightly firm when moist.

WEBSTER SERIES, CALCAREOUS VARIANT

Webster silty clay loam, calcareous variant, is calcareous throughout. In other characteristics, it is similar to Webster silty clay loam.

Webster silty clay loam, calcareous variant (NE¼ sec. 15, T. 93 N., R. 27 W.):

A_1 0 to 13 inches, black (10YR 2/1) silty clay loam to clay loam; moderate, medium, granular structure; calcareous; firm when moist; plastic when wet.
B_{g1} 13 to 20 inches, mixed black (10YR 2/1) and very dark grayish-brown (2.5Y 3/2) clay loam; weak, fine, subangular block structure; calcareous; firm when moist; plastic when wet.

B_{g2} 20 to 30 inches, mixed very dark grayish-brown (2.5Y 3/2) and black (2.5Y 2/0) clay loam; weak, very fine, subangular blocky structure; calcareous; firm when moist.

C_2 30 to 50 inches, mixed very dark grayish-brown (2.5Y 3/2) and dark olive-gray (5Y 3/2) light loam; massive; calcareous; slightly firm.

Engineering Applications[9]

This soil survey report for Humboldt 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 in 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 more 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, reports, and aerial photographs.

The map 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: A cluster of primary soil particles held together by internal forces to form a clod or fragment.

Clay: As a soil separate, mineral particles less than 0.002 millimeter in diameter. As a textural class, soil material that is 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: As a soil separate, mineral particles 2.0 to 0.05 millimeters in diameter. As a textural class, soil material that is 85 percent or more sand and not more than 15 percent silt and clay.

Silt: As a soil separate, mineral particles 0.05 to 0.002 millimeter in diameter. As a textural class, soil material that is 80 percent or more silt and less than 12 percent clay.

Soil: The natural medium for the growth of land plants on the surface of the earth, composed of organic and mineral materials.

Engineering Classification Systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials (*1*). 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. The classification of the soils of Humboldt County according to this system is given in the next to last column of table 9.

Some engineers prefer to use the Unified Soil Classification System (*19*). 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 soils of Humboldt County have been classified under this system in the last column of table 9.

Additional basic information about classification of soils by engineering methods can be obtained from the PCA Primer (*9*).

Soil Engineering Data and Interpretations

Listed in table 9 are characteristics of soils that affect their use in engineering, as well as some appraisals of their suitability as a source of topsoil and as material for highway construction. The data in table 9 are based on soil tests made by the Iowa State Highway Commission, on information given in other sections of this report, and on experience with the same kinds of soils in other counties.

Additional information about soils can be obtained from the map and from these sections of the report: General Nature of the Area; General Soil Areas; Soil Survey Methods and Definitions; Soil Series and Mapping Units; and Formation, Classification, and Description of Soils. Some of the characteristics of soils that are significant in engineering are discussed in the following paragraphs.

In Humboldt County, limestome bedrock underlies the glacial till and alluvium. In areas where the limestone is not deeply buried, a few sinkholes, or vertically drained potholes, have formed. These sinkholes are common in the northeastern part of Weaver Township and in the adjoining townships to the north and east. Sinkholes do not provide adequate support for roadway embankments or structures, and their exact location and extent should be determined during preliminary investigations.

Because of the different ways glacial till was deposited, it may be extremely variable. Predominantly the till is A–6, but it commonly contains pockets of sand or gravel, and A–7 lenses or layers of clay are not uncommon. In these glacial materials, frost heaving is a hazard where pockets of sand or gravel that hold large quantities of free water are overlain by fine-grained soil material that is within the zone of frost penetration. A perched water table may be encountered where a layer or pocket of sandy or gravelly material overlies a clayey layer.

[9] This section was prepared in cooperation with the Iowa State Highway Commission.

Although frost heaving and perched water tables are problems, the hilly to rolling Storden, Hayden, and Clarion soils are texturally the better glacial soils for highway construction. In contrast, the level to nearly level Nicollet and Webster soils have a thick, dark-colored surface soil that is commonly more than 2 percent organic carbon. Good density of these dark surface layers is difficult, if not impossible, to attain, even with control of moisture content and compaction. Hence, the surface soil of Nicollet and Webster soils should not be used in the uppermost 2 feet of highway embankments. The Glencoe and Okoboji soils and some of the other soils in depressions are excessively high in organic carbon, and, like muck and peat, are not suitable for use in embankments or foundations. If embankments cross these soils, the black horizons, high in organic carbon, should be removed.

Waterworn gravel is fairly abundant in the deposits of glacial outwash from which the Kato, Marshan, and Waukegan soils formed, and the same is true for the Dickinson soils in bench positions and for the morainic Lakeville soils. These deposits, however, are sources of high-quality material for construction. Some of the eolian sands of the Dickinson, Farrar, and Lamont soils are especially erodible. Roadway slopes in these soils should be protected from wind and water by a ground cover.

Alluvial land and the Colo, Huntsville, Wabash, and other alluvial soils on the first bottoms are occasionally flooded. Roadways constructed on these bottom lands must be on embankments above the flood level. Foundations of high embankments and bridge abutments should be thoroughly investigated for any soft material that would cause embankments to settle or be unstable. The layers of fine sand and silt common in alluvial soils are susceptible to differential frost heave; hence, proper roadway drainage should be provided. Foundation materials not susceptible to frost action should be used if pavements are to be only a few feet above the water table. The water table is seasonally variable in the alluvial soils, but the moisture content is generally high and the in-place density is low. Consequently, control of moisture and density are needed if these soils are used as embankment material.

As shown in table 9, some of the soils in this county are suitable sources of borrow material or of material used for topsoil for embankments, slopes, and ditches. The topsoil should be able to produce a good ground cover, and this was considered in rating the soils as a source of this material. Topsoil generally is unsuitable for highway shoulders that have to support some traffic during wet periods.

At many construction sites, there are major variations in a soil within the depth of the proposed excavation. Also, there may be several soil units within a short distance. Nevertheless, the soil map, the profile descriptions, and the engineering data given in this report can be used in planning. Then detailed surveys of soils can be made at construction sites. Thus, the engineer can concentrate on the most important soil units, obtain the minimum number of soil samples for laboratory testing, and make an adequate soil investigation at minimum cost.

Soil Properties Affecting Conservation Engineering

This subsection discusses soil properties in relation to construction of terraces, drainage and irrigation systems, control of gullying, and farm ponds.

Terraces

Before building terraces, consider (1) the purpose of the terraces, (2) the slope of the land, and (3) the soil material. Generally, terraces are built for two purposes. The more common of the two is to control sheet and gully erosion on sloping soils. The other is to divert water before it reaches and floods lower areas. The diversion terraces are normally larger than those used to control erosion, and they are always on a gentle grade, for the purpose is to carry away water.

Terraces can be built on any slope where earthmoving machinery can operate. The steeper the slope, the larger or closer together the terraces have to be, and, consequently, the more difficult it will be to move farm machinery over them. Terraces for control of sheet and gully erosion can be used with excellent success on slopes of less than 14 percent, and with fair to good success on slopes of 14 to 18 percent. Up to 1959, little experience had been had with terraces on slopes of more than 18 percent. Some farmers have built terraces on such slopes in the western part of Iowa and have reported that they are satisfactory.

Most soil materials, except those that are very sandy, can be used to build terraces. Sandy materials tend to drift with the wind or to slump into terrace channels and thus reduce the efficiency of the terrace. Dickinson, Lamont, Farrar, and Lakeville soils are suitable for terraces, though it is harder to keep the channels from filling than on finer textured soils. The other sloping upland soils in Humboldt County are suitable for terracing. In Humboldt County, the best outlet for a graded terrace is a grassed waterway.

Drainage

Drainage to improve crop yields is important in this county. Most used are tile drains with outlets to man-made open ditches or to natural streams. Drainage exclusively by means of open ditches is less common.

Tile drainage.—The tile system is installed to remove subsurface water and, in places, to remove surface water by way of surface intakes leading to the tile lines. Before installing tile drainage, take into account (1) the need for drainage, (2) the suitability of the soil for this kind of drainage, (3) the availability of suitable outlets for tile lines, and (4) the capacity of the proposed system to operate efficiently and economically.

The permeability of the soil determines whether or not tile drainage will work well. Tile drains do not operate satisfactorily in soils that are very slowly permeable. On such soils, they can be used to remove surface water led to them by surface intakes. Tile drains work well in soils with moderate to moderately slow permeability. On slowly permeable soils the tile lines need to be closer together and, even then, may work only fairly well. Tile is hard to install and maintain in soils having a sand or gravel substratum.

TABLE 9.—*Characteristics*

Soil series and miscellaneous land types	Slope	Brief description of soil profile and ground condition	Parent material
	Percent		
Alluvial land (Ad)	0 to 2	Extremely variable	Stratified recent alluvium
Ames (Am)	0 to 1	Poorly drained; firm silty clay loam to clay subsoil over loam material.	Glacial till
Ankeny (AnB, AnC)	2 to 9	Well drained to excessively drained; friable sandy loam to light sandy clay loam subsoil over loamy sand to sandy loam.	Sandy colluvium
Clarion (CaB, CaB2, CaC, CaC2, CaD2, CaE2, CaF2, CaG, CnB, CnC2).	2 to 50	Well drained; friable loam subsoil over calcareous loam parent material; small sand and gravel pockets may occur.	Glacial till
Colo (Co, Cp, Cr, Cs, see also CtB and CtC).[1]	0 to 2	Poorly drained; slightly firm silty clay loam subsoil; underlain in many areas by loamy sand to sand below a depth of 45 inches; high organic-matter content in top 1½ to 2 feet.	Alluvium
Copas (Cv)	0 to 2	Well drained; friable loam subsoil; limestone bedrock at depths of 18 to 30 inches.	Alluvium over bedrock
Cullo (Cu)	0 to 1	Poorly drained; firm silty clay loam subsoil over friable stratified glacial material; high organic-matter content in top 1½ to 2 feet.	Waterworked glacial till
Dickinson (DkA, DkB, DkC2, DkD2, DkE3).	0 to 20	Excessively drained; very friable sandy loam subsoil over sand or loamy sand.	Eolian sands or sandy glacial deposits.
Dickinson, bench position (DtA, DtB, DtC2, DtD2).	2 to 15	Excessively drained; very friable sandy loam subsoil over sand and gravel.	Sandy alluvium
Dundas (Du)	0 to 1	Poorly drained; firm silty clay loam to light silty clay subsoil over loam material; high organic-matter content in top 1½ to 2 feet.	Glacial till
Farrar (FaB, FaC2, FaD2)	2 to 15	Somewhat excessively drained; very friable sandy loam subsoil over loam glacial till at depths of 14 to 40 inches.	Eolian sands over glacial till
Garmore (Ga)	1 to 3	Moderately well drained; slightly firm loam to clay loam subsoil over calcareous loam glacial till; limestone bedrock ordinarily at depths of 10 to 20 feet but, in a few places, the depth is less.	Glacial till
Glencoe (Gc)	0	Very poorly drained; occurs in depressions; firm silty clay loam to light silty clay subsoil over calcareous loam to silt loam; high organic-matter content to depths of 2 to 3 feet.	Waterworked glacial till or local alluvium.
Harpster (Ha, Hc)	0 to 2	Poorly drained; slightly firm silty clay loam to clay loam subsoil over calcareous loam material; high organic-matter content to a depth of 1½ feet.	Glacial till or alluvium
Harpster, sand and gravel substratum (Hb).	0 to 2	Poorly drained; slightly firm loam to clay loam subsoil over sand and gravel at depths of 30 to 50 inches.	Alluvium or outwash
Hayden (HdB, HdC2, HdD2, HdE2, HsF).	2 to 50	Well drained; slightly firm clay loam subsoil over loam material; sand and gravel pockets may occur.	Glacial till
Huntsville (Hu, Hv)	0 to 2	Imperfectly drained; friable loam to silty clay loam subsoil over stratified loam to sandy loam alluvium.	Alluvium
Kato (KdA, KbB, KmA, KmB)	0 to 5	Imperfectly drained; slightly firm to friable clay loam subsoil; sand and gravel at depths of 24 to 36 inches or more.	Glacial outwash
Lakeville (LaC2, LaE2)	5 to 20	Excessively drained; gravelly loam surface soil over gravel.	Gravelly glacial drift
Lamont (LfB, LfC2, LfD2, LfE2)	2 to 20	Excessively drained; friable sandy loam to sandy clay loam subsoil over loamy sand or sand.	Eolian sands or wind-modified sandy glacial deposits.
Lester (LmB, LmC2, LmD2, LmE2, LsF, LsG).	2 to 50	Well drained; friable to firm loam to clay loam subsoil over loam material; sand and gravel pockets are common.	Glacial till
LeSueur (Lu)	1 to 3	Imperfectly drained; slightly firm clay loam subsoil over loam material; sand and gravel pockets are common.	Glacial till
Marshan (Md, Mm)	0 to 2	Poorly drained; slightly firm to friable clay loam subsoil; substratum below depths of 24 to 60 inches; stratified gravel containing sand and shale.	Glacial outwash (loam)
Muck and Mucky peat (Mu, Mw, Mx, My, Mz).	0	Very poorly drained; organic matter 10 to 60 inches thick over glacial drift.	Organic material over glacial drift.
Nicollet (Nc)	1 to 3	Imperfectly drained; slightly firm clay loam subsoil over calcareous loam glacial till; sand and gravel pockets may occur.	Glacial till

See footnote at end of table.

that affect soil engineering

Depth to seasonally high water table	Suitability as source of—		Engineering classification	
	Topsoil	Borrow for highway construction	AASHO	Unified
Feet				
0 to 3	Variable	Variable to poor	A–2 to A–7	SM to CH.
1½ to 3	Fair to depth of dark surface layer.	Poor	A–6 to A–7	CL to CH.
5+	Poor	Good	A–2 to A–3	SP to SM.
5+	Good to depth of dark surface layer.	Good	A–4 to A–6	SC to CL.
1 to 3	Good	Unsuitable	A–7	OH to CH.
5+	Fair to depth of dark surface layer.	Fair	A–6 to A–7	CL.
1 to 3	Fair to depth of dark surface layer.	Unsuitable	A–6 to A–7	CL to OH.
5+	Poor	Good	A–2 to A–4	SM to SC.
5+	Poor	Excellent	A–1 to A–2	SM to SP.
1½ to 3	Fair to depth of dark surface layer.	Unsuitable	A–6 to A–7	CH to OH.
5+	Poor	Good	A–2 to A–4	SM to SC.
5+	Good to depth of dark surface layer.	Fair	A–6 to A–7	CL to CH.
0 to 3	Fair to good	Unsuitable	A–7	CH to OH.
1½ to 3	Poor	Unsuitable	A–6 to A–7	CL to OH.
1½ to 3	Poor	Unsuitable above gravel	A–6 to A–7 over A–1 or A–2	CL to OH over SP to GM.
5+	Poor	Good	A–4 to A–6	SC to CL.
1 to 3	Good	Fair to poor	A–6 to A–7	CL to CH.
2½ to 3	Good to depth of dark surface layer.	Excellent below topsoil	A–4 over A–1 to A–2	SC over SC to SW.
5+	Unsuitable	Excellent	A–1 to A–2	GP to SM.
5+	Unsuitable	Good	A–2, A–3, or A–4	SM to SP.
5+	Fair to depth of dark surface layer.	Good	A–4 to A–6	SC to CL.
3+	Fair to depth of dark surface layer.	Fair	A–6 to A–7	SC to CL.
1½ to 3	Good to depth of dark surface layer.	Unsuitable above gravel	A–6 to A–7 over A–1 or A–2.	CL to OH over GP to SM.
0 to 3	Good to excellent	Unsuitable	Visual	Pt.
3+	Good to depth of dark surface layer.	Fair	A–6 to A–7	SC to CL.

TABLE 9.—*Characteristics that*

Soil series and miscellaneous land types	Slope	Brief description of soil profile and ground condition	Parent material
	Percent		
Okoboji (Ok, Op)	0	Imperfectly to very poorly drained; slightly firm silty clay loam subsoil over silt loam to silty clay loam material.	Waterworked glacial till or local alluvium.
Orio (Or)	0	Poorly drained; firm sandy clay to clay loam subsoil over highly stratified glacial drift containing layers of silt, sand, and loam.	Stratified glacial drift
Plattville (Pv)	0 to 2	Imperfectly drained; slightly firm or friable loam or clay loam subsoil over limestone bedrock at depths of 36 to 60 inches.	Alluvium over limestone
Rolfe (Ro)	0	Very poorly drained; very firm clay to clay loam subsoil over highly stratified glacial drift containing layers of silt, sand, and loam.	Waterworked glacial till or local alluvium.
Sogn (SgB)	2 to 5	Well drained; limestone bedrock within 15 inches of the surface.	Limestone bedrock
Storden (StD2, StE2, StF3, StG3)	9 to 50	Well drained; friable loam surface soil over friable calcareous loam till; no B horizon; sand and gravel pockets common.	Glacial till
Terril (TeA, TeB, TeC)	0 to 9	Moderately well drained; friable loam subsoil over loam material.	Local alluvium
Truman (TrA, TrB, TrC2, TrD2, TrE2).	0 to 20	Well drained; friable silt loam subsoil over silt loam to light silty clay loam; sand and gravel normally occur at depths of 7 to 10 feet.	Alluvium
Wabash (Wa, Wb)	0 to 1	Poorly drained; very firm silty clay subsoil over silty clay loam material.	Alluvium
Wacousta (Wc)	0	Very poorly drained; firm silty clay loam subsoil over stratified calcareous glacial drift composed mostly of silt loam and very small amounts of fine sand; high organic-matter content in topmost foot.	Waterworked glacial till or local alluvium.
Waukegan (WdA, WdB, WdC2, WmA, WmB, WmC2, WmD2).	0 to 15	Well drained to somewhat excessively drained; friable loam subsoil; stratified fine, medium, and coarse gravel below depths of 24 to 36 inches.	Glacial outwash and alluvium
Webster (Wy, Wz)	0 to 1	Poorly drained; slightly firm silty clay loam subsoil over stratified material containing lenses of silt, sand, or sandy loam; high organic-content in topmost 1½ feet.	Glacial till or waterworked glacial material overlying glacial till.

[1] CtB and CtC are complexes of Colo and Terril soils.

The services of a drainage engineer are normally needed in determining whether or not there is a suitable outlet for a tile system and to get an adequate design for the tile system. Table 3, however, will be of assistance in preliminary investigation. It summarizes the major characteristics of soil types, including their drainage and permeability.

Open ditches.—Open ditches are used to remove excess surface water or to remove water collected by other ditches or by tile drains. Shallow, open ditches that are crossable by farm machinery are effective in removing surface water from pothole soils such as the Glencoe, Okoboji, or Wacousta, and should be used in addition to tile drainage. Open ditches, both crossable and noncrossable, can be used to drain slowly and very slowly permeable soils in which tile drains do not work well. The Wabash soils, for example, are best drained by open ditches.

Before deeper, noncrossable open ditches are installed, the nature of the substratum should be considered. For example, the Marshan soils, which are underlain by sand and gravel, may require wider ditches with less steep sides than soils with loam or clay loam substrata. The wider and shallower ditches are needed to insure bank stability and adequate channel capacity.

Irrigation

Little irrigation has been practiced, but some farmers in the county have considered irrigating droughty soils. Factors to consider in planning an irrigation system are the following: (1) expected increases in yields, (2) water intake rates and the moisture-holding capacity of the soil, (3) availability of water for irrigation, (4) increased labor needs, and (5) cost of installation (*5*).

Gully control

Most gullies can be satisfactorily kept from growing by shaping with machinery and by establishing a permanent grass cover. Some gully erosion can be controlled by terraces. In gullies used for tile outlets, the tile must be extended before the gully is shaped and seeded. In these gullies, concrete structures or toe walls are needed to stabilize the grade. Technical assistance on gully control can be obtained from the Soil Conservation Service.

affect soil engineering—Continued

Depth to seasonally high water table	Suitability as source of—		Engineering classification	
	Topsoil	Borrow for highway construction	AASHO	Unified
Feet 0 to 3	Good	Unsuitable	A–7 to peat or muck	OH to Pt.
0 to 3	Poor	Poor	A–6 to A–7	SC to CH.
5+	Good to depth of dark surface layer.	Fair	A–6 to A–7	CL.
0 to 3	Fair to depth of dark surface layer.	Poor	A–6 to A–7	CL to OH.
5+	Unsuitable	Unsuitable	Variable	Variable.
5+	Unsuitable	Good	A–4 to A–6	SC to CL.
5+	Excellent	Fair	A–4 to A–6	CL to OL.
5+	Good to depth of dark surface layer.	Fair	A–4 to A–7 over A–1 to A–2.	ML to CL over GP to SM.
1 to 3	Unsuitable	Unsuitable	A–7	OH to CH.
0 to 3	Good to depth of dark surface layer.	Unsuitable	A–6 to A–7	OL to CH.
5+	Good to depth of dark surface layer.	Excellent	A–4 over A–1 to A–2	SM to SC over SP to GW.
1½ to 3	Good to depth of dark surface layer.	Unsuitable	A–6 to A–7	CL to OH.

Farm ponds

Suitable sites for farm ponds are very limited in this county because of the topography. Also, the soil material may not retain water because it is too sandy or contains strata of sand or gravel. For these reasons, technical advice should be solicited before constructing a farm pond. Each site should be bored carefully so that the soil material can be examined. Costly mistakes can be made if ponds are built without proper investigation and engineering surveys.

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GUIDE TO MAPPING UNITS AND MANAGEMENT GROUPS

[See table 5, p. 32, for management and estimated average acreage yields for cultivated soils, and table 2, p. 7, for approximate acreage and proportionate extent of soils. See pp. 64 to 69 for information on engineering properties of the soils]

Map symbol	Mapping unit	Page	Management group	Page
Ad	Alluvial land	8	15	44
Am	Ames loam	8	7	41
AnB	Ankeny sandy loam, 2 to 5 percent slopes	8	5	41
AnC	Ankeny sandy loam, 5 to 9 percent slopes	10	10	42
CaB	Clarion loam, 2 to 5 percent slopes	10	6	41
CaB2	Clarion loam, 2 to 5 percent slopes, moderately eroded	10	6	41
CaC	Clarion loam, 5 to 9 percent slopes	10	11	43
CaC2	Clarion loam, 5 to 9 percent slopes, moderately eroded	10	11	43
CaD2	Clarion loam, 9 to 15 percent slopes, moderately eroded	10	12	43
CaE2	Clarion loam, 15 to 20 percent slopes, moderately eroded	10	14	44
CaF2	Clarion loam, 20 to 30 percent slopes, moderately eroded	10	16	44
CaG	Clarion loam, 30 to 50 percent slopes	10	18	45
CnB	Clarion loam, thin solum, 2 to 5 percent slopes	11	6	41
CnC2	Clarion loam, thin solum, 5 to 9 percent slopes, moderately eroded	11	11	43
Co	Colo silt loam	11	2	40
Cp	Colo silt loam, channeled	11	15	44
Cr	Colo silty clay loam	11	2	40
Cs	Colo silty clay loam, channeled	11	15	44
CtB	Colo-Terril complex, 1 to 5 percent slopes	11	3	40
CtC	Colo-Terril complex, 5 to 9 percent slopes	11	11	43
Cu	Cullo silty clay loam	12	7	41
Cv	Copas loam	12	5	41
DkA	Dickinson fine sandy loam, 0 to 2 percent slopes	12	9	42
DkB	Dickinson fine sandy loam, 2 to 5 percent slopes	12	9	42
DkC2	Dickinson fine sandy loam, 5 to 9 percent slopes, moderately eroded	12	13	43
DkD2	Dickinson fine sandy loam, 9 to 15 percent slopes, moderately eroded	12	17	44
DkE3	Dickinson fine sandy loam, 15 to 20 percent slopes, severely eroded	13	17	44
DtA	Dickinson sandy loam, bench position, 0 to 2 percent slopes	13	9	42
DtB	Dickinson sandy loam, bench position, 2 to 5 percent slopes	13	9	42
DtC2	Dickinson sandy loam, bench position, 5 to 9 percent slopes, moderately eroded	13	13	43
DtD2	Dickinson sandy loam, bench position, 9 to 15 percent slopes, moderately eroded	13	17	44
Du	Dundas silty clay loam	13	3	40
FaB	Farrar fine sandy loam, 2 to 5 percent slopes	13	5	41
FaC2	Farrar fine sandy loam, 5 to 9 percent slopes, moderately eroded	13	10	42
FaD2	Farrar fine sandy loam, 9 to 15 percent slopes, moderately eroded	13	13	43
Ga	Garmore silt loam	14	1	39
Gc	Glencoe silty clay loam	14	7	41
Ha	Harpster loam	14	4	40
Hb	Harpster loam, sand and gravel substratum	14	4	40
Hc	Harpster silt loam	14	4	40
HdB	Hayden loam, 2 to 5 percent slopes	15	6	41
HdC2	Hayden loam, 5 to 9 percent slopes, moderately eroded	15	11	43
HdD2	Hayden loam, 9 to 15 percent slopes, moderately eroded	15	12	43
HdE2	Hayden loam, 15 to 20 percent slopes, moderately eroded	15	14	44
HsF	Hayden soils, 20 to 50 percent slopes	15	18	45
Hu	Huntsville silt loam	15	2	40
Hv	Huntsville silt loam, channeled	15	15	44
KdA	Kato loam, deep over sand and gravel, 0 to 2 percent slopes	16	1	39
KdB	Kato loam, deep over sand and gravel, 2 to 5 percent slopes	16	6	41
KmA	Kato loam, moderately deep over sand and gravel, 0 to 2 percent slopes	16	5	41
KmB	Kato loam, moderately deep over sand and gravel, 2 to 5 percent slopes	16	5	41
LaC2	Lakeville gravelly loam, 5 to 9 percent slopes, moderately eroded	16	13	43
LaE2	Lakeville gravelly loam, 9 to 20 percent slopes, moderately eroded	16	17	44
LfB	Lamont fine sandy loam, 2 to 5 percent slopes	16	5	41

Map symbol	Mapping unit	Page	Management group	Page
LfC2	Lamont fine sandy loam, 5 to 9 percent slopes, moderately eroded	16	10	42
LfD2	Lamont fine sandy loam, 9 to 15 percent slopes, moderately eroded	16	13	43
LfE2	Lamont fine sandy loam, 15 to 20 percent slopes, moderately eroded	17	17	44
LmB	Lester loam, 2 to 5 percent slopes	17	6	41
LmC2	Lester loam, 5 to 9 percent slopes, moderately eroded	17	11	43
LmD2	Lester loam, 9 to 15 percent slopes, moderately eroded	17	12	43
LmE2	Lester loam, 15 to 20 percent slopes, moderately eroded	17	14	44
LsF	Lester soils, 20 to 30 percent slopes	17	16	44
LsG	Lester soils, 30 to 50 percent slopes	17	18	45
Lu	LeSueur loam	17	1	39
Md	Marshan silty clay loam, deep over sand and gravel	18	3	40
Mm	Marshan silty clay loam, moderately deep over sand and gravel	18	3	40
Mu	Muck, moderately shallow	18	8	42
Mw	Muck, shallow	18	8	42
Mx	Mucky peat, deep	18	8	42
My	Mucky peat, moderately shallow	18	8	42
Mz	Mucky peat, shallow	18	8	42
Nc	Nicollet loam	19	1	39
Ok	Okoboji silt loam	19	7	41
Op	Okoboji silt loam, imperfectly drained variant	19	3	40
Or	Orio fine sandy loam	19	7	41
Pv	Plattville loam	20	1	39
Ro	Rolfe loam	20	7	41
SgB	Sogn loam, 2 to 5 percent slopes	20	13	43
StD2	Storden loam, 9 to 15 percent slopes, moderately eroded	20	12	43
StE2	Storden loam, 15 to 20 percent slopes, moderately eroded	21	14	44
StF3	Storden loam, 20 to 30 percent slopes, severely eroded	21	16	44
StG3	Storden loam, 30 to 50 percent slopes, severely eroded	21	18	45
TeA	Terril loam, 0 to 2 percent slopes	21	1	39
TeB	Terril loam, 2 to 5 percent slopes	21	6	41
TeC	Terril loam, 5 to 9 percent slopes	21	11	43
TrA	Truman silt loam, 0 to 2 percent slopes	21	1	39
TrB	Truman silt loam, 2 to 5 percent slopes	21	6	41
TrC2	Truman silt loam, 5 to 9 percent slopes, moderately eroded	21	11	43
TrD2	Truman silt loam, 9 to 15 percent slopes, moderately eroded	21	12	43
TrE2	Truman silt loam, 15 to 20 percent slopes, moderately eroded	21	14	44
Wa	Wabash silty clay	22	7	41
Wb	Wabash silty clay, channeled	22	15	44
Wc	Wacousta silt loam	22	7	41
WdA	Waukegan loam, deep over sand and gravel, 0 to 2 percent slopes	23	1	39
WdB	Waukegan loam, deep over sand and gravel, 2 to 5 percent slopes	23	6	41
WdC2	Waukegan loam, deep over sand and gravel, 5 to 9 percent slopes, moderately eroded	23	11	43
WmA	Waukegan loam, moderately deep over sand and gravel, 0 to 2 percent slopes	22	5	41
WmB	Waukegan loam, moderately deep over sand and gravel, 2 to 5 percent slopes	22	5	41
WmC2	Waukegan loam, moderately deep over sand and gravel, 5 to 9 percent slopes, moderately eroded	23	10	42
WmD2	Waukegan loam, moderately deep over sand and gravel, 9 to 15 percent slopes, moderately eroded	23	13	43
Wy	Webster silty clay loam	23	3	40
Wz	Webster silty clay loam, calcareous variant	23	3	40

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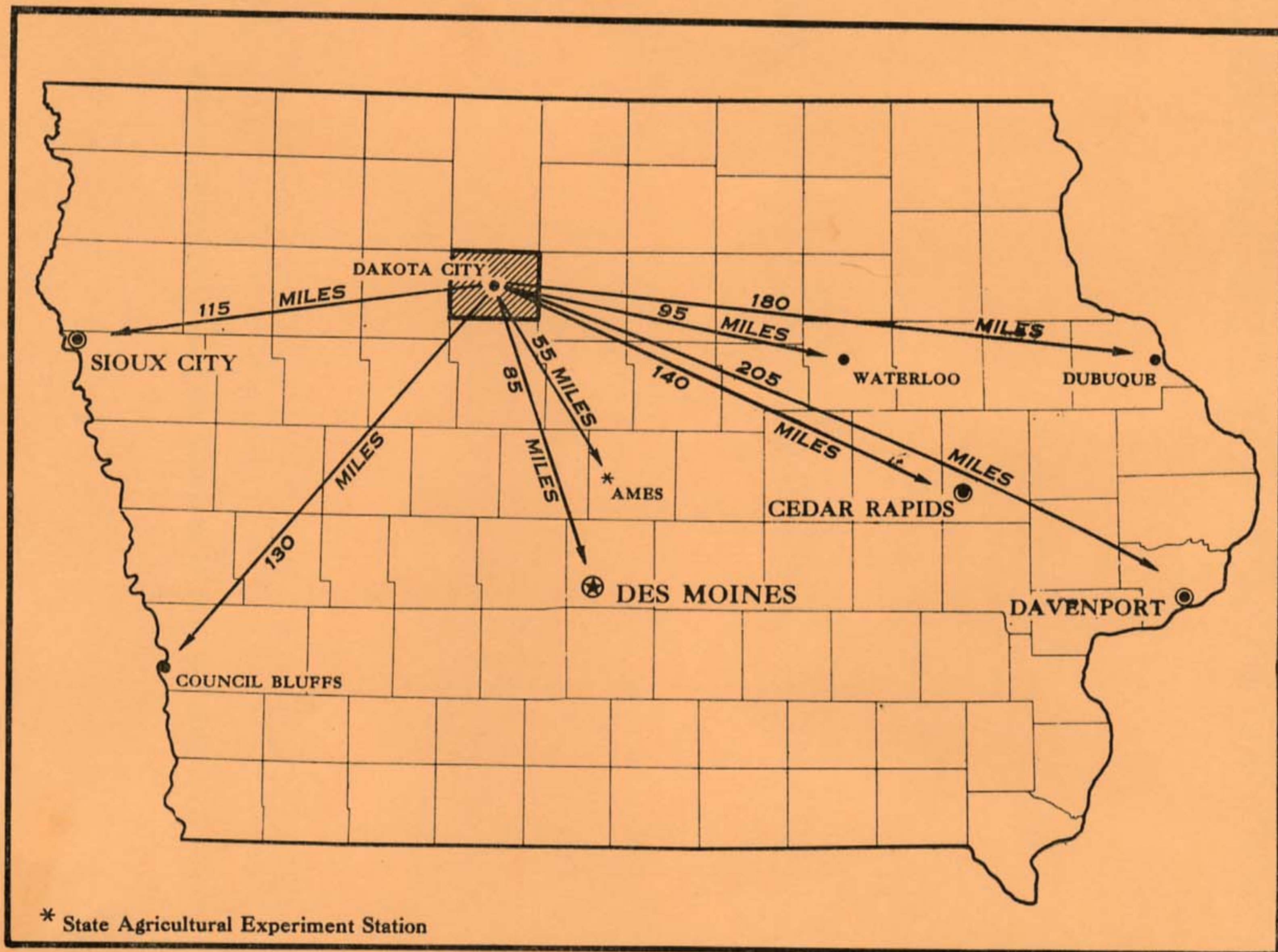

Location of Humboldt County in Iowa.