Series 1934, No. 19 Issued March 1940

Soil Survey

Osceola County Iowa

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United States Department of Agriculture

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PLANT INDUSTRY
In cooperation with the
Iowa Agricultural Experiment Station

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SOIL SURVEY OF OSCEOLA COUNTY, IOWA

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

COUNTY SURVEYED

Osceola County is in the northwestern part of Iowa, bordering the Minnesota line (fig. 1). Sibley, the county seat and largest town, is in the northwestern part. It is approximately 70 miles northeast of Sioux City, 165 miles northwest of Des Moines, and 50 miles east of Sioux Falls, S. Dak. The total area of the county is 395 square miles, or 252,800 acres.

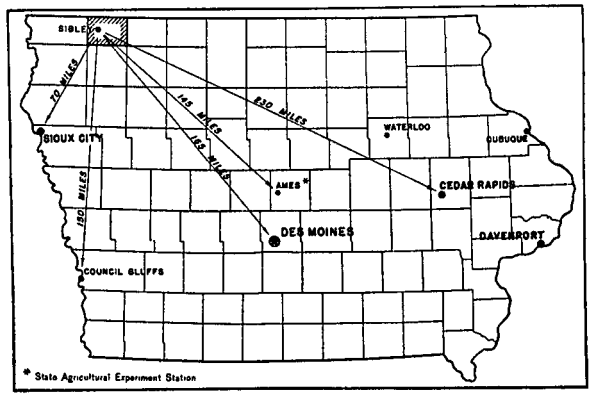

FIGURE 1.—Sketch map showing location of Osceola County, Iowa

The surface features of the county are those of a nearly flat, undulating to gently sloping plain, except in the northeastern part, where knobby kamelike ridges vary the landscape. The original plain covered by glacial drift and loess has been modified by the action of glacial waters, wind, and postglacial surface erosion. More than three-fourths of the land has a slope of less than 3 percent, in most places less than 2 percent; only about 1 percent has a slope ranging from 10 to 15 percent; and the rest has a slope ranging from 3 to 10 percent.

The largest and more nearly continuous belt of steeper slopes borders the Ocheyedan River Valley from the Minnesota line southeastward through the county and extends up along its principal tributaries, especially those projecting into the area northeast of the river and along the lower part of the Little Ocheyedan River to the west. Included in this belt is the area surrounding Ocheyedan Mound. An area that is somewhat more rolling surrounds Iowa Lake and extends southeastward to Dickinson County. In the northwestern

[1] The Soil Survey Division was transferred to the Bureau of Plant Industry July 1, 1939.

part the higher plains dip sharply from either side toward the valley of the Little Rock River. In the southwestern part, north and west of Otter Creek in Gilman Township, much of the land is moderately sloping, with the slopes exceeding 6 percent in only a few places. In the areas where the slopes exceed 10 percent, the total length of the steeper slopes is in few places more than a few hundred feet, and the difference in the relative elevations of the plains above to the bases where the slopes become decidedly more gentle in few places exceeds 50 feet. The total acreage with slopes of less than 3 percent is divided between upland and stream valleys, with about 85 percent uplands and 15 percent terraces and bottom lands. The main terrace and bottom-land areas adjoin the Ocheyedan and Little Rock Rivers, Otter Creek, and the main branches of these streams.

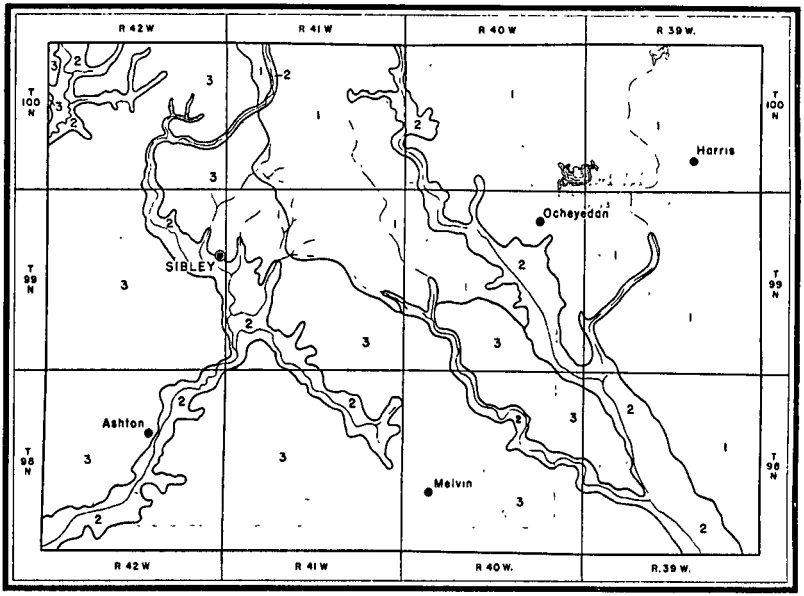

FIGURE 2.—Sketch map of Osceola County, Iowa, showing general areas of soils developed from (1) Wisconsin glacial drift, (2) alluvium, and (3) Peorian loess.

The general slope of the land in the eastern half of the county is southeastward, whereas in the western half it is largely southwestward. The slope reading taken from the top of one plain to the top of another indicates a barely perceptible slope to the south. Even when the reading is taken from the floor of the Ocheyedan River Valley to the tops of the plains several miles to the north, the rise is only a small fraction of 1 percent. When the reading is taken from the middle of the valley to the tops of the nearest slopes the reading is less than 3 percent.

The general areas of soils developed from the three classes of parent materials—Wisconsin glacial drift, Peorian loess, and alluvium—are outlined in figure 2.

The southern and western parts of the county are covered by a silty material called Peorian loess which varies in thickness. On some slopes it has been removed and the underlying glacial drift has been exposed. Such exposures may be located on the soil map as small areas of Clarion loam in the western part of the county. Toward the eastern border of the loess-covered area the silty material is thin over the older drift, and here extensive areas of Marshall silty clay loam, till-substratum phase, are developed. The deeper loess deposits are nearly coextensive on the soil map with areas of the Marshall and the Marcus soils.

The glacial drift exposed in the eastern and north-central parts of the county consists of a highly calcareous till with small areas of sandy or gravelly material here and there. This drift was deposited during the Wisconsin stage of glaciation and, being younger than the other surface materials, has not been so deeply leached, consequently its content of lime is high. The areas of Wisconsin glacial drift are almost coextensive with those in which the Clarion and the Webster soils are dominantly developed. The section covered by this drift sheet differs widely from the smooth loess-covered plain. Morainic hills and ridges are interspersed with flat lowlands, some of which are occupied by lakes and marshes.

The unusual width of the flood plains of the streams and the rather uniformly laid gravel layer or layers beneath the lower terraces and the bottom lands indicate that the volume of the water that built these wide valleys was greater than that represented by the present run-off. The alluvial materials now exposed were deposited largely by the waters of melting glaciers but were later modified by the deposition of the finer materials brought in by the floodwaters of the present streams and by local alluvium washed down from the adjacent slopes.

Osceola County is within the Missouri River drainage basin. The western part of the county is drained locally by Otter Creek and the Little Rock River. Otter Creek joins the Little Rock River in Lyon County, and their waters reach the Missouri River through the Rock and Big Sioux Rivers. The north-central and eastern parts are drained by the Ocheyedan River and its branches. The Ocheyedan River empties into the Little Sioux River several miles southeast of the county. A few of the small streams in the southern part join the Floyd River in O'Brien County. Both the Little Sioux and Floyd Rivers are tributaries of the Missouri.

The system of drainage is dendritic in form but is not well developed. The most mature drainage is in the southwestern part, southwest, west, and north of Ashton. Elsewhere in the county much of the land required artificial drainage before it could be cultivated. Much of the land surface formerly was so poorly drained that such areas were spoken of as swamplands by the early settlers. Drainage is improved largely through the use of tile in the fields and by straightening and deepening the channels of the main streams. A few open ditches in the fields, especially on the low terraces and bottom lands, are used as laterals leading to the main channels.

The highest altitudes in the State are in this county. The greatest elevation is estimated as about 1,675 feet above sea level by various

authorities, but they disagree as to its exact location. The county engineer gives its location as on or near the western county line in Viola Township. The Iowa Geological Survey (*5*)[2] places its probable location at Ocheyedan Mound, with an estimated elevation of 1,670 feet, but also states that elevations equal or nearly equal to that of the mound very likely occur on the flat divides north of Allendorf in Wilson Township. Elsewhere (*4*) Ocheyedan Mound is given as one of the highest points in the State. Ocheyedan Mound is a conspicuous feature because it rises high above the surrounding country. Elevations nearly approaching that of Ocheyedan Mound are on the flat plains north of Allendorf, which form the divide between the drainage valleys of the Ocheyedan River and Otter Creek. No figures are available for the lowest altitude, but it is the point where either Otter Creek or the Ocheyedan River leaves the county and is probably about 1,400 feet above sea level.

In addition to the estimated elevations within the county, the following known elevations of railroad stations (*1*) have definite value and are of considerable local interest: Melvin 1,581 feet, Ocheyedan 1,551 feet, Cloverdale 1,518 feet, Sibley 1,502 feet, and Ashton 1,449 feet. Melvin is the only station near the crest of a divide, and the station at Ashton is situated barely above the bottom lands of Otter Creek Valley. In general the elevations on the nearly level plains on the major divides range from about 1,550 to 1,660 feet, and those of the lowest points in the valleys are about 1,400 feet.

The native vegetation of this area was distinctly that of a typical prairie country, with tall grasses predominating. Here and there a few willows grew in the lower places, and a few poplars were scattered along the stream channels. A few black oak, bur oak (mossycup oak), basswood (American linden), elm, and a few juniper (red cedar), together with a scattered undergrowth of hazel, crab apple, wild cherry, and haw grew around Iowa Lake, the southern end of which lies in this county. Another patch of forest was in the eastern part on a small island in what was known as Grove Island Lake, a wide marshy area that now is drained. On this island the predominating tree growth was white ash, with a few soft maple, poplar, and cottonwood, and there was an undergrowth of wild cherry, hazel, willow, and haw.

Although most of the county was treeless when it was settled, trees now are common around the farmsteads. Nearly every farm has a large windbreak on the north and west of the buildings. The streets of every village are lined with trees, and many villages have small wooded parks. In addition, many farms have groves planted at some distance from the home or have rows of trees planted along the roads. The varieties of trees most commonly grown in the groves are cottonwood, boxelder, ash, soft maple, willow, and elm. Occasional orchards of apple and plum trees, together with some cherry trees, increase the number of groves. Several varieties of evergreens are becoming fairly common in the better windbreaks. Evergreens not only add beauty to the grove but also increase its usefulness as a windbreak in winter.

The boundaries of the county were established by an act of the Third General Assembly of Iowa on January 15, 1851 (*7*), but Osce-

[2] Italic numbers in parentheses refer to Literature Cited, p. 45.

ola County remained attached to Wahkaw County, later changed to Woodbury County, until it was organized as a separate unit in January 1872. Settlement of Osceola County took place somewhat later than that of surrounding counties, both in Minnesota and Iowa, because neither navigable rivers nor railroads crossed its borders.

The first homestead claim on land within the county was filed November 3, 1870, on the southwest quarter of section 32, Gilman Township; but the first settlers, including the one who filed in 1870, came in the spring and summer of 1871. Some of the settlers came from Lyon, O'Brien, and other nearby counties, but most of them came from counties farther east or from other States, especially Wisconsin and Illinois. The settlers broke enough ground to plant a few acres to potatoes, corn, turnips, other vegetables, and melons. Very little wheat was grown the first year. The influx of new settlers was fairly rapid, and by the spring of 1873 the total population numbered 1,409 people. There were 419 dwellings and 426 families. The State census of 1873 (*2*, *p. 50*), which included the agricultural statistics collected for the year 1872, the second crop year in the history of the county, reported 50 pounds of wool clipped and, from a total of 7,444 acres of plowed land, the production of crops as follows: Wheat 5,176 bushels, corn 13,862 bushels, oats 4,857 bushels, and barley 346 bushels. According to county records, the county appropriated money to pay for 4 road bridges, the first in the county, built in 1872.

According to the United States census of 1930, the population of the county is 10,182. It is well distributed, with an average of 25.8 persons to the square mile. The composition of the population is 9,080 native white, 1,047 foreign-born white, and 55 persons other than white or Negro. Emigrants from Germany and the Netherlands represent about 82 percent of the foreign-born population, and the rest came mostly from Canada, England, and the Scandinavian countries. Sibley, the county seat and largest town, has a population of 1,870. Other incorporated towns and their populations are: Ashton, 568; Ocheyedan, 627; Harris, 328; and Melvin, 301. Sibley and Ashton were laid out by the Sioux City & St. Paul Railroad in 1872, when that road was built through the county. Allendorf, May City, and Cloverdale are small unincorporated settlements.

The Chicago, St. Paul, Minneapolis & Omaha Railway (formerly the Sioux City & St. Paul Railroad) and one main line and two branches of the Chicago, Rock Island & Pacific Railway Co. afford rail transportation to all parts of the county. Farm products are marketed chiefly in Sioux City, Sioux Falls, Minneapolis, Chicago, and New York.

Nearly every section is surrounded by roads, and a few are cut by roads on the quarter lines. United States Highway No. 59 is paved from the O'Brien County line to within 1 mile of the Iowa-Minnesota line. A paved State highway extends from the Dickinson County line to Sibley and westward nearly to the Lyon County line. Another State highway is paved from the O'Brien County line to Ashton and from the latter point is graded to the Minnesota State line. In addition, many miles of county roads are graded and graveled and are passable even in wet weather. Most of the rest of the roads are graded and kept in good condition by dragging, but they may become impassable in wet weather. Because of the large supply

of good gravel available in the county, more miles of dirt roads are graveled each year.

The public-school system extends into all parts of the county. Graded schools and high schools are in all the principal towns, and rural graded schools are so located that nearly every school district comprises four sections. Most of the churches are in the towns and small villages; a few are in the rural areas.

In general, the farm homes are well-built frame structures. Many are large, but others range from moderate to small. Most of the barns are large and fairly modern in structure. Rural mail routes reach all parts of the county, but very few farm homes are connected with telephone service. Electric-power lines reach all the small towns and villages, and many farmers living along such lines make use of the power. No rural-electrification program has as yet been established.

Industry, other than that based on agriculture, depends, for the most part, on utilization of the gravel and sand beds. It includes the manufacture of concrete tiles and building blocks and the screening and grading of sand and gravel for use in concrete construction.

CLIMATE

The climate is continental, and the range in temperature between the hottest days in summer and the coldest days in winter is rather extreme. The maximum range over a period of years is from −40° to 108° F., a total of 148°. The average length of the frost-free season, from May 12 to September 25, inclusive, is 136 days, but killing frost has been reported as late as June 7 and as early as September 11. The average annual precipitation is 27.22 inches. The lowest annual precipitation on record is 15.55 inches, and the highest is 40.74 inches. The period of heaviest rainfall extends from May through September, during which time almost 70 percent of the total falls. This period coincides with the period of greatest crop growth and also with the period of greatest evaporation. Much of the rain falls in the form of slow general rains, and a part of it comes as gentle to heavy showers. Occasionally heavy rains of several inches fall within periods of 24 hours or less. The driest months are from November to February. During winter the precipitation is commonly in the form of snow, which is very beneficial, as it offers excellent protection to grasses, perennial legumes, flowering shrubs, berrybushes, plants, and fall-seeded grains.

The summers generally are warm, with a large percentage of sunshine and occasional short periods of extreme heat. The winters are about equally divided between severely cold and more moderate and pleasant weather. Blizzards are more or less common, especially in January, February, and March; but very severe blizzards may not occur over a period of several years. Tornadoes seem to be most common in May, but the county has never suffered any great damage from them. Hailstorms most commonly occur in July and August, but they seldom are very severe. Their path generally is from the northwest toward the southeast.

Table 1 presents the more important climatic data, compiled from the records of the United States Weather Bureau Station at Sibley, which are representative of climatic conditions throughout the county.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Sibley, Osceola County, Iowa*

[Elevation, 1,494 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1886)	Total amount for the wettest year (1908)	Snow, average depth
	°F.	°F.	°F	*Inches*	*Inches*	*Inches*	*Inches*
December	19.3	59	−32	0.79	0.75	0.96	4.6
January	13.2	55	−40	.61	.68	.10	6.1
February	14.7	68	−40	.71	.20	1.65	5.5
Winter	15.7	68	−40	2 11	1 63	2.71	16.2
March	30.6	85	−21	1.21	.42	1 62	4.9
April	45.6	94	10	2.21	1.67	3.26	1.7
May	57.0	94	21	4.30	1.33	10.45	.1
Spring	44 4	94	−21	7.72	3.42	15.33	6.7
June	66.0	100	32	4.18	1.20	7.82	.0
July	70.8	108	37	3.45	.40	3.87	0
August	69.4	98	33	3 60	2.40	4.58	.0
Summer	68.7	108	32	11.23	4.00	16.27	.0
September	60.6	102	15	3.41	4.10	2.07	.0
October	48.5	92	3	1.82	1.45	2.34	.7
November	32.6	75	−15	.93	.95	2.02	2.4
Fall	47.2	102	−15	6.16	6.50	6.43	3.1
Year	44.0	108	−40	27.22	15.55	40.74	26 0

AGRICULTURAL HISTORY AND STATISTICS

The agricultural history of Osceola County began with the arrival of the first settlers in 1871. The county was settled somewhat later than surrounding counties because the railroad did not penetrate the area so soon, although it was generally understood that the Sioux City & St. Paul Railroad would build a line through the western part. Accordingly, most of the settlers located in that section, but, even as early as 1871, some of the homesteaders settled near the present site of Ocheyedan. The prospects for the production of large quantities of agricultural products were good. The country was practically treeless; the soils were abundantly fertile; and, except for the large area of land too flat for good natural drainage, nearly every acre was ready for the plow. In many instances the new settler broke and planted several acres to potatoes, corn, and vegetables before he took time to build his sod house or other semipermanent dwelling. The Sioux City & St. Paul Railroad was completed to Worthington, Minn., in the fall of 1871, and the next year it was extended through the present site of Sibley. Roads were laid out and opened to the settlers.

The State census of 1873 (*2, p. 50*) reported 7,444 acres of plowed land, and that more land was being prepared for cultivation. In the spring of 1873 hordes of grasshoppers destroyed crops and pastures and threatened the livelihood of the settlers. These pests continued their visitations each year thereafter until 1880, but they were most destructive during the first 3 or 4 years. Many settlers became dis-

couraged and left the county, and the prospective settlers went elsewhere.

A comparison of the State census figures of 1873 with those of the United States census of 1880 and 1890 shows how the infestation by grasshoppers curbed the rapid settlement that had begun. The population, which was 1,409 in the spring of 1873, 2 years after the first settler came, had increased to 2,219 in 1880, a gain of only 810 in 7 years in a new area made more accessible by the completion of a railroad, the opening of many roads, the construction of bridges, the establishment of many retail stores and trade centers, and the building of schools and churches. When the grasshoppers failed to return in the early eighties, people began to think that the pest might not return, and the population began increasing more rapidly, reaching 5,574 in 1890 and 8,725 in 1900. During the next 20 years, however, the increase was less rapid. The population reached 10,223 in 1920 and then decreased to 10,182 in 1930. The entire population is classed as rural.

The number, tenure, and size of farms in census years are given in table 2.

TABLE 2.—*Number, tenure, and size of farms in Osceola County, Iowa, in stated years*

Year	Farms	Operated by—			Land in farms			Improved land in farms		
		Owners	Tenants	Managers	Total	Percentage of county area	Per farm	Total	Percentage of farm land improved	Per farm
	Number	*Percent*	*Percent*	*Percent*	*Acres*	*Percent*	*Acres*	*Acres*	*Percent*	*Acres*
1880	495	78.2	21.8	-------	87,676	34.6	177 0	60,467	69 0	122. 2
1890	838	54.2	45.8	-------	159,283	62 9	190.0	137 088	86.1	163 6
1900	1,088	56.9	42 9	0.2	246,875	97.6	226 9	236,099	95 6	217.0
1910	1,068	47.4	52 1	.5	236,406	93.4	221 4	227,692	96 3	213.2
1920	1,265	36.4	62 4	1 2	247,864	98.0	195 9	230,971	93.2	182 0
1930	1,278	31 8	67.8	4	249,000	98 5	194.8	227,549	91.4	178 3
1935	1,317	32.6	66.9	.5	251,306	99 4	190.8	219,010	87.2	166 6

Ninety percent of the farms in 1935 ranged in size from 70 to 379 acres. The average-sized farm was 190.8 acres, which is larger than in 1880 but smaller than in 1900. The recent decrease in average size is due mostly to the slight increase in the number of farms of small acreage.

Land tenure has changed with the disappearance of the large majority of owner-operated farms in 1880 to form a nearly equally large majority of tenant-operated farms in 1935. Although the number of farms increased 166 percent—from 495 to 1,317—during this period, those operated by owners decreased from 78.2 percent to 32.6 percent. Many of the renters are related to the owners, or are former owners who have become tenants on farms now owned by insurance companies, mortgage companies, and banks. About 30 percent of the tenants rent for cash and 70 percent on shares.

Wheat was the most important grain crop in 1879, with 9,746 acres reported; corn was second, with 7,912 acres; and oats third, with 4,083 acres. Ten years later oats ranked first, corn second, and wheat third. Since 1899, corn has retained first place, although oats have been a

close second. The early importance of wheat was due primarily to its ready marketability as a cash crop. The acreage in wheat reached its peak about 1899 and has declined very noticeably since 1909; in fact, it has almost disappeared.

Hay was cut almost entirely from wild grasses by the early settlers, but the farmers were not satisfied long with wild hay. In 1899 more than 10,000 acres were reported in tame hay. Although this acreage was exceeded by the acreage of wild grass mowed, it produced more than two-thirds of the hay cut for that year. Alfalfa, now the most important hay crop, was first reported in 1919, when it was cut from 386 acres. The increase in acreage was very rapid, and 7,598 acres were reported in 1934. The county agent estimated that in 1937, 65 percent of the farmers depended chiefly on alfalfa for their hay supply.

In 1929 the value of field and orchard crops, vegetables, and farm-garden produce was $4,076,579. Cereals, with a value of $3,479,837, were the principal items.

The acreages of the principal crops, given in table 3, show the trend in agriculture.

TABLE 3.—*Acreages of principal crops in Osceola County, Iowa, in stated years*

Crop	1879	1889	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn	7,912	19,526	46,011	58,395	70,115	82,789	70,118
Oats	4,083	23,664	36,271	58,380	70,087	70,584	62,919
Barley	831	11,592	34,372	10,156	2,327	13,610	15,789
Wheat	9,746	14,564	45,195	414	925	166	264
Rye	218	87	17	154	48	488	795
Flax	-------	12,145	3,939	268	110	488	2,345
Potatoes	-------	590	876	1,174	949	1,033	934
Sugar beets	-------	-------	-------	-------	-------	1,514	-------
All hay	4,284	23,549	23,203	32,439	26,113	15,356	[1] 23,717
Timothy or timothy and clover	-------	-------	-------	21,498	15,535	5,169	2,341
Clover alone	-------	-------	271	259	500	1,363	[2] 1,268
Alfalfa	-------	-------	-------	-------	386	5,303	7,598
Other tame hay	-------	-------	10,525	831	654	304	[1] 12,510
Wild hay	-------	-------	12,407	9,851	9,038	3,217	[3]

[1] Includes 2,275 acres of sorghums for silage, hay, and fodder.
[2] Sweetclover only.
[3] Included with other tame hay.

The program of the individual farmer of today does not differ materially from that of the early settlers, except in the production of wheat. Despite the importance of wheat as a cash crop to the early settlers, they did not practice one-crop farming but also raised cattle, fattened hogs, kept a farm flock of chickens, and commonly raised a few sheep. The value of livestock sold and slaughtered in 1899 was $385,146; of dairy products sold, $41,618; and of poultry raised, $43,536. The 1910 report shows a marked increase in value of all those products. Livestock sold and slaughtered in 1909 was valued at $810,802; dairy products, excluding those used in the home, $167,564; and poultry and eggs, $131,871.

The value of butter, cream, and whole milk sold in 1929 was $588,280, and the greater part of this income was derived from the sale of 1,227,156 pounds of butterfat for $564,492. Most of the butterfat is handled by the cooperative creameries, made into butter, and sold through their organization on the New York market. The total pro-

duction of milk in that year was 4,828,828 gallons; in 1934 it decreased slightly to 4,515,557 gallons.

Poultry is most commonly sold to local buyers as live birds. Very little is dressed and shipped. The value of poultry raised in 1929 was $258,068. The 308,299 chickens raised were valued at $249,722, and 136,465 of their number were sold alive or dressed. The 1,241,752 dozens of chicken eggs produced were valued at $335,273. Most of the eggs—945,548 dozens—were sold and brought a cash income of $255,298. In 1934, the number of chickens raised decreased to 259,491, and the number of eggs produced dropped to 999,593 dozens.

The number and value of livestock in 1900, 1910, 1920, 1930, and 1935 are given in table 4.

TABLE 4.—*Number and value of livestock in Osceola County, Iowa, in stated years*

Livestock	1900		1910		1920		1930		1935 [1]
	Number	Value	Number	Value	Number	Value	Number	Value	Number
Cattle	20,469	$1,062,349	28,620	$646,132	32,556	$1,633,716	25,848	$1,505,875	37,994
Horses	7,696		8,616	916,558	10,456	917,739	8,317	725,696	7,270
Mules, asses, and burros	130		141	16,950	138	16,130	324	29,219	273
Sheep	8,856		6,395	32,804	7,088	91,672	11,330	91,988	28,879
Swine	40,122		31,669	319,843	55,019	1,369,597	58,256	831,027	43,914
Goats	11		21	54	10	47	9	46	31
Poultry	112,624	34,204	119,289	59,287	161,111	151,412	[2] 207,949	[2] 168,439	[2] 206,281

[1] Value not reported.
[2] Chickens only.

The number of horses on the farms decreased from 10,456 in 1920 to 7,270 in 1935, but the decrease in draft power furnished by horses is offset by the increased use of tractors. The largest number of swine reported for any census year is 58,256 on April 1, 1930. In comparison, the 43,914 swine reported on January 1, 1935, is considerably less, but the census of 1935 was taken before the large output of spring pigs was farrowed and is not truly comparable with the census of April 1, 1930. The largest number of cattle reported is 37,994 on January 1, 1935. This is a gain over the number reported on April 1, 1930, but, again, the difference in time of taking the report is important because most of the cattle placed into the feed lots commonly are not ready for the market until the following January, February, or March; and, furthermore, the price for cattle was so low during the late summer and fall of 1934 that many farmers held their cattle over to another season. The numbers of sheep have increased sharply from 6,395 in 1910 to 28,879 on January 1, 1935. The latter figure includes many lambs brought in for feeding but excludes the spring lambs dropped before April 1.

The average farm herd of beef cattle contains about 45 head, and the average dairy herd consists of 10 milk cows and a number of heifers and calves for replacement purposes. The average number of pigs raised per farm is 60, of which 75 percent are farrowed in the spring and 25 percent in the fall. About 280 carloads of cattle are raised in the county and placed on outside markets each

year. In addition to the cattle raised, about 120 carloads of stockers are brought in during the spring and summer to be pastured and later placed in the feed lots, and another 160 carloads of feeders are fattened in the fall and winter. About 3,600 carloads of hogs are raised and marketed, and about 300 carloads of feeders are brought in to fatten for the market. The number of sheep, breeding stock and lambs, kept or raised annually is placed at 25,000, and in addition 500 carloads of feeder lambs are brought in for fattening. The average farm flock of chickens consists of 200 birds, including about 50 hens held over and 150 pullets, and the average number of chickens raised on each farm annually for market is about 300. Practically every farmer raises chickens; 5 percent raise turkeys; 10 percent raise ducks; and 5 percent raise geese. About 5,000 turkeys, 4,000 ducks, and a much smaller number of geese are raised annually.[3]

Some of the early settlers used oxen, and some have used mules ever since the county was settled, but up to recent times the main source of draft power has been horses. At present, however, tractors are rapidly displacing horses. About 95 percent of the farmers use horses for all or part of their farm work, 5 percent use mules, and 60 percent use tractors for more or less of their field work, in addition to their horses or mules. Probably not more than 10 farms are completely motorized with tractors for power and trucks and cars for transportation. Nearly all farmers have passenger automobiles, and many have trucks.

Shorthorn, Hereford, and Aberdeen Angus are the most common breeds of beef cattle, and Holstein-Friesian and Guernsey the most common dairy breeds. Poland China, Duroc-Jersey, Chester White, and Hampshire are the leading breeds of swine, and Shropshires and Hampshires predominate among the sheep.

Barnyard manure is the most common soil amendment used. Only 58 farms reported the purchase of commercial fertilizer in 1929, at a cost of $10,063. Some is used by individual farmers more or less to experiment with field crops, and a part is used on gardens, especially in the towns. Most of the fertilizer is ready-mixed, and the common mixtures are 4–12–4 and 2–20–10.[4] The comparatively large number of cattle, horses, sheep, and swine raised and fed and the ample supply of bedding available tend to produce a large supply of manure. The farmers realize the value of the manure and use it to good advantage. The most common practice is to haul the manure directly from the barn to the fields at cleaning time and spread it. Barnyard and feeding lots are cleaned at intervals, and the litter is spread on the fields.

The greater part of the work on most of the farms is performed by the farmer and his family, with help during busy seasons. On many farms such extra help as is needed is obtained by the interchanging of labor between neighbors. Many farmers hire additional help during the busy season, others require extra help throughout the growing season, and a few use extra help throughout the year. Most of

[3] These and similar estimates given throughout the report are based on information furnished by the county agent.

[4] Percentages, respectively, of nitrogen, phosphoric acid, and potash.

the extra help is of local origin, but about 10 percent is of outside or transient origin, and most of the transients are farmers or extra farm help from South Dakota. In 1929, 921 farms reported the hire of labor, paying a total of $268,267 in wages, or $291.28 a farm reporting.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers, or horizons, called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [5] and its content of lime and salts are determined by simple tests.[6] Drainage, both internal and external, and other external features, such as relief, or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. Areas of land, such as coastal beach or bare rocky mountainsides that have no true soil, are called (4) miscellaneous land types.

The most important group is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Marshall, Clarion, and Lamoure are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Clarion loam and Clarion silty clay loam are soil types within the Clarion series. Except for the texture of the surface soil, these soil types

[5] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality, higher values indicate alkalinity, and lower values indicate acidity.

[6] The total content of readily soluble salts is determined by the use of the electrolytic bridge. Effervescence on the application of dilute acid indicates the presence of carbonates, ordinarily calcium carbonate ($CaCO_3$).

have approximately the same internal and external characteristics. The soil type is the principal unit of mapping, and because of its specific character it is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a variation within the type, which differs from the type in some minor soil characteristic that may have practical significance. Differences in relief, stoniness, and the degree of accelerated erosion are frequently shown as phases. For example, within the normal range of relief for a soil type, there may be areas that are adapted to the use of machinery and the growth of cultivated crops and others that are not. Even though there may be no important difference in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though these differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, and miscellaneous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The soils of Osceola County are, for the most part, dark-colored and rich in organic matter. They are developed from two principal kinds of parent material—Peorian loess in the southwestern half of the county and Wisconsin glacial drift in the northeastern half. Both the loess and the drift originally were highly calcareous. Leaching has not been very severe, because of a combination of fairly low precipitation, soil textures that are moderately heavy, and the high base cycle of the abundant grass vegetation. Only a small proportion of the soils, therefore, is acid in the surface soil. The soils have developed under grass vegetation in a temperate climate where the rainfall is less than 30 inches. They are characterized by deep very dark grayish-brown or black surface soils over brownish-yellow, pale-yellow, gray, or mottled gray, yellow, and brown subsoils. The depth of the dark surface layer ranges from less than 8 inches in some of the light-textured well-drained soils to more than 30 inches in some of the lower lying soils. The moderately heavy textured soils on the gentle slopes and flat divides have surface soils ranging from 18 to 24 inches in thickness. The content of organic matter ranges from a very high figure in some of the poorly drained muck or mucky phases to a rather low one in some of the steeper or more rolling sandy or gravelly soils. The texture, position, and drainage of the soils have been very important factors in the accumulation and retention of the organic matter.

General farming, including the production of such crops as corn, oats, hay, and barley, together with the raising of either beef cattle and hogs or dairy cattle and hogs, dominates the agriculture. All

farmers produce minor crops and raise poultry, especially chickens, and maintain vegetable gardens for home use. This section is naturally well suited to the production of feed crops and pasture grasses. Only a few of the steeper slopes along the main drainage valleys, the bottom lands subject to occasional overflow, some of the more poorly drained uplands and terraces, and a few very gravelly or stony spots are not well adapted to the production of crops. Grazing is the best use for much of the bottom land along the larger drainageways, most of the poorly drained areas in the uplands and terraces, and most of the areas with slopes greater than 8 percent. Where the steep areas are very small and are surrounded by larger areas of tillable soils, it is convenient to utilize them as pastures, and under such conditions it is frequently advisable to use them as hay land.

At the present time all the soils and phases mapped in the county must be regarded as tillable. Many of the soils now under cultivation required artificial drainage before they were entirely suitable for tillage. Areas that did not require tiling include the more open sandy or gravelly soils, such as the fine sandy loams of the Clarion, Dickinson, and Sioux series, the rolling phase of Clarion loam, and some very favorably situated areas of other soils. The Webster soils, Afton silty clay loam, Lamoure silty clay loam, Marcus silty clay loam, a part of Clarion silty clay loam, Benoit silty clay loam, and somewhat less of Hancock silty clay loam were considered too wet for tillage before artificial drainage was established. Only a few areas of Lamoure silty clay loam have been improved and placed under cultivation, but much of the land is so situated that under more intensive farming a large proportion can be used for tilled crops.

The soils have been grouped in 11 soil series and separated for more complete description into 17 soil types and phases, in addition to muck. The principal soil parent materials are loess, glacial drift, and the alluvium derived either from the loess, the drift, or a mixture of the two. The loess covering occupies a larger acreage than do the other soil parent materials in the southwestern half of the county, but the average thickness is much less in this county than it is farther south or west. It is thickest on the nearly flat divides, but in few places does it exceed 48 inches and probably nowhere 60 inches in thickness. The loess covering becomes thinner toward the north and east, where the underlying drift approaches the surface. The loess becomes thinner also in passing from the upper levels toward the base, where the drift or a modification of the drift and the loess is exposed in many places. The soils of the Marshall, Marcus, and Afton series are developed from the loess. The Wisconsin glacial drift occupies most of the northeastern half and gives rise to soils of the Clarion, Webster, and Dickinson series. The areas of alluvial soils border the major and the minor drainageways throughout the entire county. The soils of the Fargo, Hancock, Benoit, and Sioux series on the terraces and the Lamoure series of the stream bottoms are formed from alluvium.

In the following pages the soils are described in detail and their agricultural relationships are discussed; their distribution is shown on the accompanying soil map; and table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Osceola County, Iowa*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
Marshall silty clay loam	43,328	17.1	Webster loam	1,984	0.8
Marshall silty clay loam, till-substratum phase	28,672	11.3	Dickinson fine sandy loam	4,480	1.8
Marcus silty clay loam	16,320	6.5	Hancock silty clay loam	7,424	2.9
Afton silty clay loam	14,848	5.9	Benoit silty clay loam	3,584	1.4
Clarion loam	35,648	14.1	Fargo silty clay loam	3,520	1.4
Clarion loam, rolling phase	4,800	1.9	Sioux fine sandy loam	5,824	2.3
Clarion silty clay loam	14,976	5.9	Lamoure silty clay loam	25,472	10.1
Clarion fine sandy loam	13,184	5.2	Muck	1,920	.8
Webster silty clay loam	25,472	10.1	Total	252,800	
Webster silty clay loam, mucky phase	1,344	.5			

MARSHALL SERIES

The soils of the Marshall series have very dark grayish-brown or nearly black mellow friable surface soils. The structure generally is fine granular near the surface and somewhat more compact in place, with slightly coarser granules in the subsurface layers. The texture is commonly somewhat finer in the subsurface layers and in the upper subsoil layers than it is throughout the rest of the soil. The subsoils are light brown or brownish yellow and have a granular structure. The substratum, where the loess is sufficiently deep, is pale yellowish-brown highly calcareous silty clay loam; but in most places in this county it is highly mottled brown and in some places it is a gray highly calcareous glacial till. The silty clay loam and a till-substratum phase of that type are mapped.

Marshall silty clay loam.—Marshall silty clay loam occurs in the better drained positions in the loess area where the loess is at least 30 inches thick. The land is gently rolling or nearly flat. In general, slopes range from less than 1 to about 3 percent. The maximum slope is probably less than 6 percent, even in the more rolling areas, which include not more than 5 percent of the soil. Typically developed areas are in the southwestern part north and west of Ashton and west of Sibley near the Lyon County line.

The following description is of a profile in an area where the loess is more than 48 inches deep and that is situated at a point where the relief ranges from nearly level in the north and west to a slope of about 3 percent toward the southeast, thereby affording better external and internal drainage than is typical of the soil in this county. The surface soil to an average depth of 12 inches is very dark grayish-brown or nearly black mellow acid very finely granular silty clay loam, and the next lower layer is similar in texture and consistence but is very slightly lighter in color. Between depths of 22 and 31 inches there is a gradual transition from the dark color of the layers above to the yellowish brown of the layers below. The reaction in this layer is neutral. Below this and continuing to a depth of 40 inches the material is yellowish-brown silty clay loam. The structure is massive, but the material breaks into fairly soft clods. The reaction is neutral to alkaline. The next lower layer resembles the overlying layer except that it is faintly streaked with gray. The material when treated with acid effervesces mildly at a depth of 40

inches and strongly at a depth of 52 inches. The soil rests, at a depth ranging from 50 to 55 inches, on calcareous till containing glacial gravel and boulders.

This description of Marshall silty clay loam represents the type as it has developed in the better drained areas more deeply covered with loess and indicates its true relationship to the soil as mapped in other areas. The profile described, however, differs from a large proportion of the soil as mapped in the county because the loess over the till is predominantly less than 40 inches thick and ranges from about 30 to 36 inches in thickness over large areas.

Natural drainage ranges from fair to good, on the gently rolling or gently sloping areas, to restricted on the gently undulating or nearly flat areas. The depth to the heavy gritty clay, or glacial till, is also an important factor in drainage, because the till is more compact and less pervious to the movement of moisture than the loess. Under similar relief, depth of aeration and oxidation of the lower horizons and depth to which the free carbonates have been leached are less in areas with a loess covering from 30 to 40 inches thick than they are in areas with a loess covering ranging from 40 to 50 or more inches in thickness. In places where the covering of loess is thin the entire profile is commonly neutral to alkaline in reaction. Here and there, there is a sandy layer in the upper part of the glacial drift materials, but it varies considerably from place to place and in many places is practically or entirely absent. If this layer were continuous and had an outlet, it should aid the lateral movement of ground water, but it is doubtful whether it is continuous in any large areas. The lower layers of the profile are commonly paler yellow or more gray in the nearly flat areas than in the areas with more relief.

Marshall silty clay loam is closely associated with Marcus silty clay loam, on the wide nearly flat areas, and with Marshall silty clay loam, till-substratum phase, on the very gentle slopes. Transitions from one soil to the other are very gradual, and more or less arbitrary boundary lines are necessary. In the northwestern part of Viola Township east of the Little Rock River are a few small areas that contain more sand in the surface soil and upper part of the subsoil than is typical. This additional amount of sand is due in places to a higher sand content in the parent material and in other places to the deposition of drifting sand over the heavier loess. These areas would be separated as Marshall fine sandy loam if the total area mapped were not too small to warrant the establishment of a separate soil type on the map. Under normal moisture conditions the productive value of these small areas is but slightly less than that of the typical soil. In wet years the included soil has an advantage over the typical soil, as far as tillage is concerned, but in very dry years crops suffer more quickly on the more sandy soil. The thickness of the dark surface layer ranges from less than 12 inches in the more sharply rolling areas to more than 24 inches in some of the flatter areas, but in most places the range is from about 18 to 22 inches.

Marshall silty clay loam is one of the most important soils in the county, both from the point of view of agricultural use and of extent. It covers a total area of 67.7 square miles. It has many desirable features, including its usually good external and internal drainage,

mellow granular structure, and freedom from boulders and cobblestones. Its high content of organic matter, ready penetrability to roots, good moisture-holding properties, and fair to good permeability for the movement of moisture favor high productivity.

Nearly every acre of this soil available for tillage is cultivated, except the small areas devoted to pasture and tame hay. Natural drainage was sufficient for cultivation of the soil when the county was settled and has been improved by artificial drainage of closely associated poorly drained soils. Improvement of drainage has followed the use of tiles and has been aided by the grading of roads around practically every section.

Marshall silty clay loam is well suited to the production of all the general farm crops grown. Corn, oats, and hay are the main crops, but such crops as barley, flax, wheat, potatoes, garden vegetables, and orchard fruits are grown also. A small area is devoted to farm wood lots. According to the Iowa Agricultural Experiment Station records, corn yields approximately 50 bushels an acre, oats 50 bushels, barley 35 bushels, and alfalfa hay 2.8 tons. The use of manure or superphosphate increases the yields from 8 to 12 percent for corn, 12 to 30 percent for oats, 15 to 33 percent for barley, and 7 to 30 percent for alfalfa hay. Winter wheat shows a marked response to the use of superphosphate.

Marshall silty clay loam, till-substratum phase.—The till-substratum phase of Marshall silty clay loam occurs in areas where the depth of the loess over the glacial till ranges from 24 to 30 inches. Such areas occur on lower slopes, below the areas more deeply covered by loess and on the nearly flat divides or level plains along the eastern edge of the loess deposits. External drainage is better on the gentle slopes than in the typical positions. Many of the slopes are very gentle, few being more than 2 percent, and the heavy glacial clay is close to the surface. As a result much seepage water from the higher lying Marshall soils moves down the slopes over the heavy glacial till, fills the soil, and sometimes results in a high water table. In many places the soil appears to be slightly more compact and probably a little heavier on the slopes because the loose mellow surface soil has been partly removed by sheet erosion. In many places the dark surface layer is from 20 to 24 inches thick and reaches to the underlying till. The material is neutral to alkaline in reaction and generally effervesces with acid at depths ranging from 18 to 26 inches and averaging about 24 inches. In a few places no calcium carbonate was noticeable in the loess, but small lime fragments always were present in the upper drift material. Below the dark surface layer, the loess generally is rather grayish yellow, but a decidedly yellow color may predominate. The upper part of the underlying till is predominantly gray or grayish yellow, mottled with darker yellow and brown. About 36 inches below the surface the till is mottled yellow and brown heavy gritty clay, with gray mottling in places.

Marshall silty clay loam, till-substratum phase, is extensively developed along the eastern border of the loess-covered plain and covers a total area of 44.8 square miles. Nearly all of the soil available for tillage is in cultivated crops, plowable pastures, or in

hay lands. All this land can be cultivated except those small areas that form part of the homesteads, roadways, or farm wood lots. Drainage of both the flat land and the gentle slopes has been improved by tiling.

Corn, oats, and hay are the principal crops, but any of the crops grown on other soils in the county are adaptable to this soil. Sheet erosion is slight, but some gullying has taken place, especially in places where slopes converge. Care should be used not to allow this destructive action to continue. Corn yields average about 40 bushels an acre, oats 45 bushels, barley 35 bushels, and alfalfa 3 tons.

MARCUS SERIES

The soils of the Marcus series are formed from loess and are developed on nearly flat to very gently undulating or sloping relief. Few, if any, of the slopes exceed 2 percent. The Marcus soils resemble the Marshall soils in that the surface soils are finely granular and mellow, but they differ from those soils in having unleached free carbonates at a depth of only about 24 inches in most places and in having a somewhat deeper dark-colored surface layer that is neutral to alkaline in reaction. In the better drained areas the color of the subsoil is rather uniform light yellow or light yellowish brown and may or may not be faintly mottled with brown. In the more poorly drained flat areas the color is more gray, and mottlings of yellow and brown are common, especially in the lower part. One type, the silty clay loam, occurs in this county.

Marcus silty clay loam.—Marcus silty clay loam lies on the large flat uplands in the loess plain. It occurs in rather large nearly continuous belts on the wide, almost flat divides west of Sibley, southeast and north of Melvin, and between Ashton and Melvin. Natural external drainage is slow; owing to the flat surface, and internal drainage also is slow, owing to the heavy texture of the glacial till that underlies the loess at a depth ranging from 35 to 45 inches. The parent material is the same as that of Marshall silty clay loam.

The surface layer of Marcus silty clay loam to an average depth of 14 inches is very dark grayish-brown or nearly black granular silty clay loam. The material in the lower part of the layer is slightly firmer in place and when broken is more distinctly granular than the material in the upper part. Under optimum moisture conditions the mass is friable and mellow, but when slightly wet it becomes plastic and sticky. The reaction is neutral. The next lower layer, which continues to a depth of about 20 inches, is somewhat looser and less granular than the surface layer. Below this is a transitional layer, in which the color changes to yellowish brown and the reaction is alkaline. Below a depth of 24 inches the material is calcareous and effervesces freely when treated with acid. The mass presents a variegated appearance, generally yellowish brown mottled with gray or grayish yellow. In many places black stains of organic matter in the form of tongues penetrate this layer from the layers above. The mottled effect persists below a depth of 32 inches, but the colors are generally lighter, owing to the presence of streaks of light-gray powdery limy material and a few concretions of lime. The soil formed from loess is underlain at a depth of about 40 inches by calcareous glacial till.

Marcus silty clay loam is developed under a vegetation of tall prairie grasses. The very deep dark soil is well suited to the production of farm crops, especially grains. Natural drainage, both external and internal, ranges from slow to very slow. Artificial drainage, therefore, was required before much of this soil could be placed into satisfactory condition for farming. Grading the roads has aided drainage considerably, but tiling and open ditches were used earlier in most areas. Not many open ditches are in use on this soil today. The range of moisture conditions optimum for plowing and other tillage is much narrower than in Marshall silty clay loam. When worked under optimum moisture conditions, however, this soil forms a mellow desirable seedbed. It is no less productive than Marshall silty clay loam. In years of somewhat-less-than-average rainfall yields are very good, but in years of heavier-than-average rainfall yields may be rather small. About 25 square miles of this soil are mapped.

Practically all of the soil available for tillage is under cultivation. Corn, oats, and hay are the chief crops. Because of the damage suffered during wet years, yields average less than on Marshall silty clay loam. Hay crops usually are very good, but unless the haying weather is very favorable it is frequently difficult to dry the hay satisfactorily. Where tile drainage is fully adequate, corn yields about 35 bushels an acre, oats 35 bushels, and barley 30 bushels; but yields are considerably lower on inadequately or poorly drained fields. On exceptionally well drained areas yields may average higher.

AFTON SERIES

The Afton soils are developed from loess under conditions of restricted drainage. These soils resemble the Marcus soils in profile characteristics but differ from them in topographic position. The Afton soils occupy poorly drained swales and depressions, whereas the Marcus soils are on flat to undulating uplands. Drainage is poor, chiefly because of run-off and seepage from the higher land. Some areas are easily drained by tile or ditches and, when so improved, are highly productive, especially for corn. Afton silty clay loam is identified in this county.

Afton silty clay loam.—Afton silty clay loam is derived from loess and occurs in small depressions on the flat upland plains, generally surrounded by areas of Marcus silty clay loam. The thickness of the loess from which it is derived ranges from about 20 to more than 40 inches and averages about 36 inches. Included with mapped areas of this soil are small depressions where the loess is so shallow that many boulders project above the surface or lie just below the surface. In places these depressions have shore lines sufficiently distinct for the outlines of former shallow ponds to be traced. A few larger areas at or near the boundaries between the loess and glacial till are included, in which the soil resembles the typical Afton soils in many respects, although it is developed from a somewhat different parent material.

The surface soil is very dark gray, brownish-gray, or black silty clay loam, which, in general, is mellow and granular at the surface but rather compact and fairly stiff at a depth of 8 or 10 inches. The dark surface layer ranges from 18 to 24 inches in thickness and is

underlain by a gray, light yellowish-gray, yellow, and brown heavy silty clay or clay subsoil with a massive structure. In places the loess mantle is shallow and the subsoils are formed from glacial till. Free carbonates are present in many places at the surface, but in some places they lie more than 24 inches below the surface. Efflorescence of salts, mostly gypsum and lime, can be seen in many places on the surface of plowed fields or on the sides of freshly cut road grades or ditches. In places only the upper 8 or 10 inches appear to have a structure favorable to the penetration of roots, whereas in other places, perhaps only a few feet away, the roots penetrate readily to a depth of 24 or more inches. Natural drainage is slow in the bottoms of the depressions but is somewhat better on the slopes.

Approximately 23 square miles are mapped. Under natural conditions this land is not well suited to cultivation, but at present 75 percent or more of it has been drained and improved for tillage, leaving only the marked depressions undrained. Many depressions have been drained for the purpose of improving the large surrounding areas of other soil types rather than for the direct purpose of improving the small areas of this soil. The same crops that are planted on the surrounding areas are planted in these depressions, and the well-drained areas return high yields of corn. Small grains make a rank growth, however, and often lodge. Average yields of all the common crops are less than on the associated soils, unless drainage is exceptionally good. Crops may readily suffer damage from both the standing surface water after heavy rains and the slow internal drainge of the lower part of the subsoil. The inherent fertility is fully as high as for the surrounding soils.

A variation of Afton silty clay loam occurs in fingerlike swales at the heads of drainageways where they penetrate the upland. The lower parts of these drainageways are occupied by Lamoure silty clay loam, which merges with Afton silty clay loam so gradually that the boundary lines between the two are difficult to draw. Under natural conditions these areas of Afton silty clay loam were too wet for cultivation, but, because they penetrate into larger areas of tillable land and are a hindrance in cultivation, most of them have been tiled and are included in cultivated fields. Some areas with more slope have been left in grass to prevent gullying and appear as narrow belts or triangles of green extending into the surrounding fields. About one-half of the area of Afton silty clay loam, mostly in the southwestern part of the county, represents this variation. Given adequate drainage, the Afton soil is very productive, and as high yields can be obtained on it as on any other soil in the county. Most of the areas, however, are not sufficiently drained to prevent damage to crops from excessive moisture in wet seasons.

CLARION SERIES

The soils of the Clarion series are derived from the highly calcareous Wisconsin glacial till. They occupy the better drained positions of the upland, which may have a varying surface configuration—rolling, gently undulating, gently sloping, or nearly flat. The Clarion soils occur in close proximity to the Webster soils, which occupy the poorly drained positions within the same uplands. In many places the two soils are even more intricately associated than can be

shown on a map of the scale used. The Clarion soils are characterized by deep, very dark grayish-brown or nearly black surface soils over brown or brownish-yellow heavier materials. The color in the lower part of the profile varies according to the character of relief and internal drainage, both of which influence aeration and degree of oxidation. In the better drained areas the upper layers generally are slightly acid near the surface and medium acid in the lower part. The subsoils commonly are calcareous about 24 inches below the surface. In nearly every area, however, and especially in the heavier textured soils, some of the surface layers are neutral to alkaline in reaction. Cobblestones and boulders, ranging from a few inches to several feet in diameter, are widely scattered throughout the drift material either on the surface or throughout the soil, but very stony areas are rather uncommon.

Three types of the Clarion series, the silty clay loam, the loam, and the fine sandy loam, and a rolling phase of the loam are differentiated. The silty clay loam and the loam have in many places deep surface soils and rather light grayish-yellow or yellowish-gray subsoils. Throughout a large part of the area included in these two soil types, the reaction of the surface soils is neutral to alkaline, and only in the well-drained positions has it become acid. The sandy loam and the rolling phase of the loam are predominantly acid in the surface soils and in many places acid in the upper part of the subsoils.

Clarion loam.—As mapped in this county, Clarion loam is probably more variable in texture than either the silty clay loam or the fine sandy loam types of the Clarion series. In sections where the heavy textures predominate, the transition between the loam and the silty clay loam is very gradual. In some places the boundaries between Clarion loam, Clarion fine sandy loam, and Dickinson fine sandy loam are very definite, but in other places it has been necessary to draw them more or less arbitrarily. Areas of Webster soils too small to be shown separately are included with Clarion loam. Cobblestones and boulders are not uncommon, but their distribution is irregular. Fewer but larger boulders are generally present in the areas where the textures are finer, whereas pebbles and cobblestones are more numerous where the coarser textures predominate.

In a grass-covered area, Clarion loam has a 3-inch surface layer consisting of very dark grayish-brown or nearly black slightly acid finely granular loam. The soil is held together by grass roots, forming a sod. This layer is underlain, to a depth of 9 inches, by a layer of very slightly lighter colored and more compact material. The next lower layer is dark grayish-brown heavy loam continuing to a depth of about 20 inches. It shows a slight change toward a lighter color and a finer consistence. The next lower 6-inch layer, which is transitional in color from the dark grayish brown of the upper layers to the yellowish brown of the layer below, consists of gritty clay loam or clay. Below this is yellowish-brown gritty clay faintly mottled with gray, with no definite structure. The reaction is neutral to slightly alkaline. This layer rests on brown highly calcareous gritty clay mottled with yellow and gray. This is the parent material, a calcareous glacial till that is little altered by weathering or soil-forming processes.

The material throughout the profile contains more or less gritty substances, such as gravel, pebbles, cobblestones, and here and there a boulder. The profile described above represents the soil fairly well, except that the drainage is slightly better than average and carbonates have been leached to a greater depth. Lime is reached at a depth of about 30 inches in most places, but in many of the flatter positions the soil is neutral to alkaline, and calcium carbonate is present at a depth of less than 24 inches.

Clarion loam, in general, has the same nearly flat, gently undulating, or sloping topography as Clarion silty clay loam in the till area, but it includes more slopes than the silty clay loam. Many small areas have slopes in excess of 3 percent, but very few have slopes exceeding 6 percent, except a few more or less isolated spots too small to show as Clarion loam, rolling phase. The relative quantities of fine and gritty materials are more variable in the loam than in the silty clay loam, and the variations may occur anywhere within the profile. The texture ranges from gritty or gravelly loam in some places to heavy loam or clay loam in others. The change in texture is rather abrupt in some places, but most of the more extremely gritty areas are small and should be considered as inclusions rather than as typical Clarion loam. The larger areas of gravelly materials are remnants of kames or eskers and are included with Clarion loam because their total area is so small.

Clarion loam, of which 55.7 square miles are mapped, is the most extensive soil in the county developed from glacial drift and is second in area to Marshall silty clay loam. It is a very important agricultural soil and is suited to all the leading farm crops. Yields vary widely with the texture and relief. In most areas the texture is that of a loam or heavier material, and both the cropping systems and the yields compare closely with those on the silty clay loam. Calcium carbonate is generally leached to a greater depth in Clarion loam than in the silty clay loam, because internal drainage is better. As a result of the better drainage, crops suffer less from excess moisture on the loam. Although its inherent fertility and organic-matter content are less than in the silty clay loam, its slightly more favorable physical condition and slightly better drainage make it equally as desirable as that soil for general farming.

Clarion loam, rolling phase.—The rolling phase differs from typical Clarion loam in topographic position. The slopes range from about 6 to 15 percent, but very few exceed 10 percent. Only a small area is mapped, chiefly in the north-central and northeastern parts of the county, along the valleys of the Ocheyedan River and its branches, and to less extent along the Little Rock River Valley and along the upper part of Otter Creek Valley. As mapped, this soil includes some small rolling areas that have a sandy loam texture.

About 75 percent of the land is under cultivation, and probably 15 percent, once cultivated and later abandoned, is now included in permanent pastures. The remaining 10 percent represents extremely sloping or stony and gravelly areas. Probably 50 percent of the rolling phase of Clarion loam now under cultivation should be kept more or less permanently in hay crops or placed in permanent pastures or woodlands. Both sheet erosion and gullying have been very active in some areas, and most of the land has suffered some loss through ero-

sion. In badly eroded areas the present soils effervesce at the surface when dilute acid is applied. The same crops are grown as on the surrounding or adjoining land, but average yields are less.

Clarion silty clay loam.—As mapped in this county, Clarion silty clay loam includes two profile variations. One occurs on the lower slopes below Marshall silty clay loam, till-substratum phase, where the loess material is less than 24 inches thick. In those positions, the loess becomes gradually thinner until the present surface soil consists of a mixture of loess and glacial till. In places the texture of the surface soil is silty clay loam, but in other places a considerable amount of coarser materials, such as coarse sand, gravel, and pebbles, is mixed with the finer materials. The subsoil materials are derived mainly from the glacial till. The second and more extensive variation occurs on nearly flat, gently undulating, or sloping uplands in the drift area, in the northwestern part of the county. The parent material in the latter location presumably is glacial till, but local wind-blown or water-laid deposits apparently have modified large areas of the till so that the surface soil in many places contains large quantities of well-assorted fine materials and is practically free from gravel or pebbles. The subsoils in the latter positions also are developed mainly from glacial till. The soil, therefore, is more uniform than might appear on superficial examination or on conclusions based on the origin of the parent materials.

In a plowed field the upper 8-inch layer of Clarion silty clay loam is dark grayish-brown or black silty clay loam, which breaks when exposed to the weather, into firm angular or subangular fragments. Under optimum moisture conditions it works up to a fine mellow seedbed. In a grassy area the upper 3 or 4 inches is finely granular silty clay loam containing an abundance of grass roots and a high proportion of organic matter. When worked too wet the soil puddles, and when plowed too dry it forms clods. Cloddy fields exposed to the weather over winter, however, generally can be worked into a fine mellow seedbed in spring. The surface soil is underlain, to a depth of about 22 inches, by very dark grayish-brown clay loam or silty clay loam. This material is firmer in place than the surface soil, but it breaks readily into a loose granular mass. When wet it becomes plastic and sticky. In the lower part of this layer the color is caused by a thin coating of black organic matter over the structure particles, which become brown when crushed. The reaction is neutral or alkaline. The next lower layer is transitional in color between the dark grayish-brown upper layers and the yellowish-brown layers below, and it consists of somewhat plastic and sticky gritty clay with a massive structure. It is slightly calcareous at a depth of 22 inches and highly calcareous at a depth of 26 inches, below which lies calcareous glacial till.

Clarion silty clay loam is one of the more important agricultural soils in the county. It occurs mainly on the lower very gentle slopes within the loess areas and on the nearly flat uplands in the till areas. Natural drainage, both external and internal, is somewhat slow, but fairly good to good drainage is now provided artificially, mainly by tiling. As mapped, this soil includes small areas of Clarion loam and the Webster soils and, in the till plain, small spots of more gravelly materials. All these areas are too small to be

shown separately on a map of the scale used. Because of the very gradual changes in texture and in drainage conditions, the boundaries between this soil and the associated soils necessarily are more or less arbitrary. The total area is 23.4 square miles. Nearly all of this land can be tilled and is now either under cultivation or in tillable pasture or hay lands. A few large boulders are noticeable here and there, but smaller boulders and cobblestones are not so numerous as on the loam and fine sandy loam.

This soil is well suited to the production of all general farm crops, especially corn, grown in the county. It is fertile and has a high organic-matter content, good water-holding properties, and a relatively high water table. Crops are apt to suffer more from too much moisture than from too little. Yields of corn average more than 50 bushels an acre in favorable years. Yields of 75 or more bushels have been reported, but during wet years the yield may fall below 35 bushels. Most hay crops do very well, but, unless the weather is good during the haying season, it is difficult to dry the hay on this heavy soil. Pasture grasses do very well, and grains grow luxuriantly. Yields of small grains, especially of oats and barley, vary considerably from year to year, depending on the moisture conditions. Too much moisture frequently produces too much straw.

Clarion fine sandy loam.—Clarion fine sandy loam occurs in areas of irregular shape throughout the undulating to rolling territory in the extreme northeastern part of the county, following the Ocheyedan River and its branches from the Minnesota State line southeastward nearly to May City. It has developed from glacial till containing a greater percentage of sand than did the parent material of Clarion loam and Clarion silty clay loam, and it has a more rolling surface than the loam. Drainage in most places ranges from good to excessive, but in places it may be somewhat slow, especially internal drainage. Clarion fine sandy loam differs from Dickinson fine sandy loam mainly in the character of the lower part of the subsoil and the substratum. In typical Clarion fine sandy loam the lower subsoil or upper substratum is gritty clay or gritty clay loam, but in typical Dickinson fine sandy loam the sandy materials continue for some depth below the subsoil. The two soils overlap more or less, because the parent material from which they developed was not laid down uniformly. They have similar surface soils, occupy predominantly undulating to rolling relief, and generally have good to excessive drainage.

The 7-inch surface layer of Clarion fine sandy loam consists of dark grayish-brown friable sandy loam containing fine sand, coarse sand, and gravel. The reaction is slightly acid. The surface layer is underlain by dark grayish-brown sandy loam or fine sandy loam containing less coarse materials. Between depths of 14 and 20 inches is grayish-brown or grayish-yellow sandy loam, which grades into yellowish-brown sandy clay. The material is slightly acid to neutral in reaction. Below this and continuing to a depth of 30 inches, the material is a slightly more compact brownish-yellow friable neutral to alkaline gritty clay. The material, which has no definite structure, is yellow gritty clay splotched with light gray, owing to the presence

of finely divided carbonates. Pebbles and small glacial boulders are numerous in this layer.

Cobblestones and boulders are scattered over the surface in places, and are more common through the profile and parent material. In cultivated areas most of the boulders and larger cobblestones have been removed from the surface.

The texture of the surface soil ranges from fine sandy loam to gravelly loam. As mapped, this soil includes small areas of Clarion loam, Dickinson fine sandy loam, and, here and there, Webster soils. Some of the more steeply sloping areas are included with Clarion loam, rolling phase, because the extent of such areas was not sufficiently large to warrant establishing a rolling phase of the fine sandy loam. The total area is 20.6 square miles, most of which is under cultivation or in tillable pastures.

The type of agriculture and the relative importance of the various crops are about the same as on the heavier Clarion soils. The range in moisture conditions under which the soil can be worked satisfactorily is greater in the fine sandy loam, and less power is required to plow and till the soil than with other members of the series. The natural organic-matter content is lower and the rate of oxidation is more rapid, however, than in the heavier textured soils. Therefore, in order to maintain the soil in its most productive state, the addition of sufficient raw organic matter is essential to replace the lost humus and to keep the soil at or near the natural humus content. Livestock feeding or dairying, together with the practice of returning the manure to the fields, is undoubtedly the most suitable program for maintaining productivity.

Yields vary more from place to place on the fine sandy loam than on the heavier textured Clarion soils because of the greater variation in relief and correspondingly greater variation in drainage. On the flatter areas, yields compare favorably with those obtained on Clarion loam, but on the rolling or more steeply sloping land, the average yields often are reduced by drought or by the washing out of plants in the late spring and early summer during heavy downpours. Corn, oats, hay, and barley are the main crops. Although the average acre yields are somewhat less, the quality of the oats and barley frequently is better on the fine sandy loam.

WEBSTER SERIES

The Webster soils are developed from glacial till in poorly drained upland positions, under a grass vegetation. They are so closely associated with the Clarion soils that the elevation of the Clarion above the Webster may be only a few inches. The Webster soils occur in slight depressions without natural surface drainage or in continuous swales or depressions with very inadequate outlets for surface drainage. Internal drainage is very slow in either position, owing primarily to the heavy texture of the clay parent material. The reaction is neutral to alkaline, and calcium carbonate is present throughout the entire soil profile in some places and is leached to a depth of 48 or more inches in other places. The soils of the Webster series are characterized by their thick, very dark brown, or black, surface soils, which grade into gray or mottled brown, yellow, and gray subsoils.

Artificial drainage is required before they can be tilled satisfactorily, but when properly drained they are among some of the most productive soils in the county. Two types and one phase are separated on the map.

Webster silty clay loam.—Webster silty clay loam is the most extensive Webster soil in this county. It occurs both in nearly continuous chains of areas and in small separate areas throughout the eastern half of the county, totaling 39.8 square miles. Because of the slow external and the very slow internal drainage under natural conditions, this soil required artificial drainage before it could be cultivated satisfactorily. At present nearly all of the land is tile drained and cultivated.

The 2-inch surface layer of a grass-covered area consists of very dark grayish-brown or black mellow finely granular silty clay loam with a high content of organic matter. This layer is permeated with and held together by small grass roots and coarser rootstocks. The reaction is neutral. The surface layer is underlain to a depth of 12 inches by very dark grayish-brown or black heavy silty clay loam, which, under optimum moisture conditions, crushes to a friable finely granular mass. When wet it is slightly sticky and plastic. Gritty particles, consisting of fine and coarse gravel, are somewhat more numerous in the lower part. The next lower layer, which continues to a depth of 18 inches, is similar in color to the layer above but has a more massive structure, is somewhat more compact in place, and is slightly heavier in texture. The material is neutral to alkaline in reaction. Below this dark-colored material is light yellowish-gray somewhat gritty clay, streaked with gray calcareous material. Below a depth of 40 inches the oxidized calcareous glacial till is reached. The till is variable in composition but commonly consists of gray heavy gritty clay stained or mottled with yellow and brown. In a few places there are layers of bluish-gray clay. Boulders and glacial gravel are present in places in the upper layers of this soil, and they are abundant in the lower layers and in the till.

Webster silty clay loam is very well adapted to the production of corn, the principal crop. Yields of corn are smaller in wet years (about 25 bushels an acre) and larger in drier years (about 45 bushels). Yields as high as 75 bushels have been reported from certain areas. Because few fields are comprised wholly of this soil, accurate averages are not easily obtained. Oats and barley may do well in drier years, but under average conditions they frequently lodge rather badly. This soil is not well adapted to the production of alfalfa because of the high water table. Other hay crops do very well, but hay is not easily cured on this comparatively low lying heavy soil unless the haying season is marked by very favorable weather. Pasture grasses do very well.

Webster silty clay loam, mucky phase.—The position occupied by the mucky phase differs from that of typical Webster silty clay loam, because natural surface drainage was almost completely cut off from an outlet and water covered the land for long periods each year. Under more or less continuous wet conditions, the remains of dead grasses, reeds, and mosses accumulated and formed a layer of peat over the mineral soils. After drainage was improved, either naturally or artificially, and the peat had decayed, a mucky covering

remained, which contained 40 percent or more of organic matter intermixed with fine mineral materials. This is a nearly black or very dark brown well-decomposed organic layer, from 2 to 12 inches thick, and it overlies material similar to the surface layers of the Webster soils but is not so thick as the corresponding layer in the typical soil.

Under present conditions there is adequate provision for the removal of surface water from this mucky soil, but all the areas cannot be placed under cultivation. The most common use of this soil is for pastures and hay lands, but some of the better drained areas are used for the production of cultivated crops. Potatoes, corn, oats, and barley give fair to good yields, but some of the small grains lodge readily.

Webster loam.—The topography of Webster loam resembles that of Webster silty clay loam, whereas the profile and the adaptability to crop production, after artificial drainage, closely resemble those features of the associated Clarion soils. As mapped, the texture ranges from sandy loam to silt loam but averages more nearly a heavy loam. Only a small total area is mapped in small bodies scattered throughout the eastern part of the county, especially east of the Ocheyedan River, southeast of May City, and about 5 miles northeast of Sibley. The areas southeast of May City are associated with Dickinson fine sandy loam and approach a silt loam in texture. Most of the Webster loam has been drained and is under cultivation. The same crops are grown and about the same yields are obtained as on Webster silty clay loam.

DICKINSON SERIES

The soils of the Dickinson series are formed from sandy glacial till modified more or less with glacial outwash. The parent materials consist largely of rather deep deposits of sands or sand and gravel, containing large enough quantities of finer materials to impart a sandy loam texture. In places the light sandy loam material extends far below the true soil profile. In the typical profile the calcium carbonate is leached to a depth of about 48 inches, and in some places it is leached below a depth of 60 inches. Gravelly layers underlie the soil in many places and here and there are near the surface. Where the gravel is coarse and contains pebbles or cobblestones, leaching of calcium carbonate has not, as a rule, penetrated very far into the gravelly layer, even where that layer is near the surface. Only one type of the Dickinson series is mapped in this county.

Dickinson fine sandy loam.—Dickinson fine sandy loam is similar to Clarion fine sandy loam in topographic features. Areas of this soil range from nearly flat to rolling. Profile development varies greatly, because the parent material differs from place to place, ranging from fairly uniform fine sandy loam to interbedded layers of fine sandy loam, sand, and gravel. Included in mapping, because of their small extent, are eskers, kames, and gravelly knolls, some of which are not tillable and are used as gravel pits. The total area of this soil is not large.

The surface soil of Dickinson fine sandy loam to an average depth of 9 inches consist of dark-brown or dark grayish-brown sandy loam.

The material is slightly compact in places but in general consists of a loose friable mass that is very easily penetrated by plant roots. The surface soil is underlain to a depth of about 13 inches by brown heavy sandy loam that crumbles readily to a friable mass. Below this is yellowish-brown sandy clay grading into sandy loam or light sandy loam with depth. Below a depth of 48 inches the material is light-gray or mottled gray and brown sandy loam or light sandy clay. The reaction is acid down to this layer, which ranges from acid to neutral. Calcium carbonate is present within 36 inches of the surface in places where the subsoil rests on coarse gravelly material. Boulders are not common on the surface but may be fairly numerous in the lower part of the profile. Most of the areas surrounding eskers and kames contain more boulders throughout the soil profile.

Dickinson fine sandy loam has approximately the same agricultural value as Clarion fine sandy loam and, like that soil, varies widely in productivity. The nearly flat, gently undulating, and gently sloping areas are productive. Naturally they are not so fertile as the finer textured soils, but, under intelligent management whereby the organic-matter content is maintained, very satisfactory crops can be produced. The soil is easily tilled and can be worked under a very wide range in moisture content. Some of the more rolling areas, especially the sandy or gravelly ones, are not very satisfactory for farming. Yields in the more rolling areas vary greatly according to the season and may be rather disappointing in dry seasons. Corn, oats, barley, and hay are the main crops.

HANCOCK SERIES

The soils of the Hancock series occupy comparatively flat terrace positions and have slow to fair external drainage. Even though the soils are almost universally underlain by gravel at a depth ranging from 40 to 72 inches, internal drainage is comparatively slow. Near the outer edge of the terrace, where it lies relatively high above the adjoining bottom lands, drainage may range from good to excessive. The depth to which the free carbonates are leached ranges from less than 14 to more than 48 inches, but calcium carbonate is reached in most places at a depth of 36 inches or less. The reaction is commonly neutral in the surface soil and neutral or alkaline in the subsoil, although both layers are acid in places. Internal drainage and profile development of the better drained areas of the Hancock soils compare favorably with those features of Marshall silty clay loam, but they correspond more closely to those of Clarion silty clay loam. The Hancock soils are characterized by very dark surface soils, which grade into yellowish-gray or brown subsoils. Only the silty clay loam type is mapped.

Hancock silty clay loam.—Hancock silty clay loam occupies most of the higher terraces and many of the comparatively low ones along Otter Creek and the Little Rock River. Some scattered areas occur along the Ocheyedan River and its tributaries. The total area is 11.6 square miles. The largest bodies are in the vicinity of Sibley and extend southeastward toward Melvin.

The surface layer of Hancock silty clay loam, to an average depth of 12 inches, consists of very dark grayish-brown or nearly black heavy silt loam or silty clay loam, with a very finely granular structure.

This layer, under natural conditions, is filled with fine grass roots and coarser rootstocks. The reaction is neutral. Below this, and continuing to a depth of about 18 inches, is dark grayish-brown silty clay loam, which grades downward into grayish-brown silty clay loam. The next lower layer is grayish-brown almost structureless neutral to alkaline silty clay loam, which rests on grayish-yellow silty clay loam or clay. This material is massive in structure and is strongly calcareous.

In most places a thin layer of gravel intervenes between the upper soil material and the underlying glacial till, especially toward the outer edge of the terrace, but the gravelly layer becomes thin or disappears near the uplands. Several large gravel pits have been worked in the areas southeast of Sibley near the outer edges of the terrace, where it breaks down to the bottom lands. The gravel continues under the flat terraces but in most places is so deeply covered with finer materials that most of the pits are abandoned after the more thinly covered gravel has been removed.

The best drained areas are near the outer border of the comparatively high terraces. Both external and internal drainage become slower toward the uplands. Distinct breaks between the terraces and the uplands do not occur everywhere, because the slopes merge gradually with the flatter terraces, and here only arbitrary separations can be made. In other places the breaks are definite. Similar conditions exist between the terraces and the bottom lands. As mapped in this county, this soil includes small areas of Hancock loam and Benoit silty clay loam.

Hancock silty clay loam is one of the most important terrace soils, and practically all of it is under cultivation. The crops produced are similar to those produced on Marshall silty clay loam, Clarion silty clay loam, and Clarion loam. Yields are good and compare well with those obtained on the upland soils mentioned. This soil is well suited to the production of alfalfa, except where the internal drainage may require improvement in the flatter positions. The lime content generally is sufficient for alfalfa, and it is doubtful whether any benefit would result from the application of additional lime to the soil.

BENOIT SERIES

Members of the Benoit series have very dark colored surface layers and are underlain by porous sands or gravel. Owing to their low position, the Benoit soils have developed under conditions of poor drainage and have a high water table, and many areas remain waterlogged throughout the year. In this respect they differ from the Sioux soils, which occur on high terraces and have adequate or excessive drainage. Benoit silty clay loam is mapped in this county.

Benoit silty clay loam.—Benoit silty clay loam occurs mainly along the Ocheyedan River and its branches and to less extent along Otter Creek and the Little Rock River. In most positions it occupies terraces lying only slightly above the bottom lands, but in places there are two distinct levels, the second only slightly higher than the first. The land is nearly flat, except for slight depressions or slightly elevated crests within the larger areas. A few less typical areas lie at the bases of the upland slopes, especially where lateral drainage-

ways enter the valley. The relief varies more in such areas. The boundaries between the uplands and the terraces are less definite than those between the terraces and bottom lands. Many of the slopes covered by this soil represent a continuation of the upland slopes, which merge almost imperceptibly into the true terraces. The gravelly layer generally present under the true terraces is lacking in places.

In the more typical areas the depth to the underlying gravel ranges from 26 to 42 inches and averages about 32 inches.

The surface soil ranges from 18 to 22 inches in thickness and in general is nearly black, but it becomes more gray with depth. The upper part is mellow and very granular. The subsoil is brown or yellowish gray and is more or less mottled or streaked in most places as drainage becomes poorer. The latter condition is more common. Calcium carbonate is present in the surface soil or is leached to a depth ranging from a few to 24 or more inches. In the less typical areas that border smaller streams or lateral drainageways, the deposition of gravel appears to have been more irregular, as gravel is exposed on the surface in some places and is absent in others. Under natural conditions, both external and internal drainage were slow on the low wide terraces. Internal drainage was slow because of the high water table. With the present improved drainage, effected chiefly by straightening and deepening the stream channels and by the use of tiles and lateral ditches to take care of the water from the nearby slopes or small intermittent drains, fairly good crops may be grown. If the water table is lowered too far, however, injury may result during prolonged droughts.

The total area of this soil is small. It is a desirable soil for crops, and more than 90 percent of the land is under cultivation or in tillable pastures and hay lands. Corn, the principal crop, yields an average of about 35 bushels an acre, although much higher yields are reported on some areas. Killing frosts damage the corn earlier in fall on this soil than on other soils, because of its comparatively low position. Oats and barley are important small-grain crops and yield about the same as on the heavy-textured soils of the flat uplands.

FARGO SERIES

The soils of the Fargo series, as differentiated in this county, have nearly black surface soils underlain by gray or mottled brown and gray heavy calcareous subsoils. These soils are developed, under fair drainage conditions, on old lacustrine terraces and low terraces along streams. They differ from the Benoit soils mainly in the heavy texture of the lower part of the profiles, overlying silt and clay instead of sandy or gravelly materials. Only the silty clay loam is mapped in this county.

Fargo silty clay loam.—The largest areas of Fargo silty clay loam are in the southeastern part of the county in the valley of the Ocheyedan River. Several smaller bodies border the upper tributaries of this river or occupy depressions in the northeastern part of the county. Several areas occur in the vicinity of Sibley, between Sibley and Melvin, and along the Little Rock River.

The surface soil of Fargo silty clay loam is very dark grayish-brown or nearly black silty clay loam ranging from 12 to 18 inches in thickness. It is underlain by dark-gray heavy clay that is faintly tinged with yellow but becomes more yellow with depth. Beginning at a depth of about 25 inches is grayish-yellow clay streaked with black and containing iron and lime concretions. The upper two layers do not everywhere contain calcium carbonate, but the lowest layer is highly calcareous.

Natural surface drainage is restricted. Nearly all of the areas can be drained, however, by tiling or ditching, and in many places this has been done. The heavy texture does not allow as free movement of water as can take place in the corresponding layers of Benoit silty clay loam; on the other hand, the Fargo soil, owing to its higher position, does not have the waterlogged condition of the Benoit soil.

Under similar drainage conditions, the drained areas of Fargo silty clay loam are about as productive as areas of Webster silty clay loam. Yields vary according to the seasons and are smaller in years of heavier rainfall. The average yield of corn on improved land is about 40 bushels to the acre. Oats and barley return good yields only in years of low rainfall; in other years these crops make a rank growth and lodge badly. In places where the water table is not too high, the soil is well suited to alfalfa.

SIOUX SERIES

The soils of the Sioux series are characterized by dark surface soils grading into brown or brownish-gray subsoils, which are underlain by a gravelly layer. In Osceola County much of Sioux fine sandy loam, the only type mapped, occupies very low terraces and has a fairly deep covering of fine materials over the gravel and a comparatively high water table. The areas in this county are better agriculturally than is commonly expected of the Sioux soils in other counties.

Sioux fine sandy loam.—Sioux fine sandy loam typically occupies nearly flat land but includes some fairly steep slopes on the higher terraces. It also is developed on some of the outer edges of the higher terraces of Hancock silty clay loam, where the covering of the finer materials is thinned by erosion. Included in mapping are small bodies of a soil that would be separated as Sioux silty clay loam if they were larger. Gravel generally is present from 14 to 18 inches below the surface and in some places is exposed at the surface. Calcium carbonate occurs at or near the surface, except in the higher terrace positions bordering Hancock silty clay loam, where leaching has removed the carbonates to a depth of 40 or more inches.

The 8-inch surface layer is typically dark-brown or brown loose fine sandy loam. Its texture ranges from light gravelly loam in some places to heavy fine sandy loam in others. In general, the soil contains a fairly high proportion of medium to coarse sand. The soil material becomes slightly heavier in texture and lighter in color with increasing depth, in many places changing to yellowish-brown gritty sandy clay immediately above the gravel. The lower two

layers vary considerably in thickness, are generally well drained, and in few places are mottled. Gravel commonly occurs scattered over the surface of cultivated fields.

Sioux fine sandy loam covers an area of 9.1 square miles, chiefly along the Ocheyedan and Little Ocheyedan Rivers and Otter Creek. Probably 70 percent of the land is cultivated or represents improved pasture or hay land, and the rest, which includes the slopes on the higher terraces and some of the more extremely gravelly areas, is largely in permanent pasture of native grasses. Under natural conditions the water table was comparatively high in typical areas, and in most places it remains fairly high, a condition that is beneficial to the production of crops on this type of soil. Despite the flatness of the land, external drainage is not noticeably slow, owing to the slight depth to gravel, and internal drainage ranges from good to excessive. On the high terraces, both external and internal drainage are excessive. Corn, oats, barley, and hay are the chief crops. Yields range from fair to good in most years but may be reduced severely during prolonged droughts. Yields on this soil correspond to those obtained on Clarion fine sandy loam and Dickinson fine sandy loam.

LAMOURE SERIES

The surface soils of soils of the Lamoure series are nearly black; the subsoils are dark grayish brown, dark grayish yellow, or mottled gray, yellow, and brown; and the substrata are predominantly gray, mottled with yellow and brown in places. These soils are developed from alluvium deposited along the streams and small drainageways. Lamoure silty clay loam is the only member of this series mapped in this county.

Lamoure silty clay loam.—Lamoure silty clay loam occurs on the bottom lands of all the major streams and drainageways and, in most places, is subject to overflow in times of high water. The land in the wider bottoms is nearly flat. In some of the narrower bottoms the surface configuration is very irregular because of the meanderings of the stream channels. Surface drainage ranges from fairly good to slow, and internal drainage commonly is slow. Many of the wider bottom lands are underlain by beds of gravel, but the high water table prevents good internal drainage. Very little improvement in drainage can be made except by deepening and straightening the main channels. Improvement of drainage in the more suitable places should be accompanied by providing other places for retaining the water in the area and thereby aiding in the maintenance of the supply of ground water.

The surface soil is very dark grayish brown or black to a depth ranging from 18 to more than 26 inches. It is underlain by gray or light bluish-gray heavy massive clay, which is mottled, in places, with yellow and brown. In some places, the soil is calcareous near the surface; in others it is leached of calcium carbonate to a depth of 30 or more inches.

Although the soil has a fairly uniform texture throughout most of its area, some variations do occur, which are related to the velocity of the water that deposited the parent material. Most of the

variations, however, occur in such an erratic pattern that a separation was impracticable. A few large areas, especially along Otter Creek southwest of Ashton, contain a higher proportion of sand than is typical. The sandy material is commonly of recent origin and has been deposited along existing channels over the former surface soils. Included also are small areas covered with muck to a depth ranging from 3 to 14 inches.

Lamoure silty clay loam is an important soil, both in extent and in use. A total of 39.8 square miles is mapped, of which probably 70 percent is used for permanent pasture and provides an abundant supply of good grasses. Most of the remaining 30 percent is under cultivation, principally to corn, which has been grown for many successive years in some places. Yields vary widely, depending on the seasons, and are reduced by extremely wet or cool weather.

MUCK

Muck contains 40 percent or more of organic matter intermixed with mineral soil materials. The areas mapped have a dark-brown or nearly black organic covering from 12 to 24 inches thick. In some areas the upper material is largely well-decomposed peat containing very little mineral matter. Most of the mucky areas are calcareous near the surface. The soil material beneath the muck, as a rule, consists of gray gritty clay and, in some areas, of well-assorted fine silt and clay. Most of these areas have been drained. Some of this land is devoted to cultivated crops, chiefly potatoes, corn, oats, and barley, but most of it is used for tame hay or remains in permanent pasture. On the cultivated areas yields range from fair to good during favorable seasons, except that small-grain crops are very apt to lodge.

LAND USES AND AGRICULTURAL METHODS

The soils of Osceola County are well suited to a farm program that includes the production of feed crops, grazing and feeding beef cattle, dairying, and raising hogs. The principal crops are corn, hay, and barley. In addition a number of minor crops are grown, mostly vegetables and supplemental feed crops. A considerable acreage of sugar beets was reported in 1929 and of flax in 1934. On the average-sized farm of about 190 acres, 35 percent of the acreage is devoted to the production of corn, 30 percent to grains other than corn, 20 percent to pasture, 10 percent to hay, and 5 percent to other cultivated crops, such as potatoes, sorghums, soybeans, sugar beets, and home-garden vegetables. More than one-third of the hay acreage is in alfalfa. Approximately 70 per cent of the pasture consists of native grasses and plants, 25 percent is seeded to sweetclover or timothy, and the remaining pastures are partly improved and partly native. As commonly used, the term "native grasses and plants" includes grasses and plants that have become so well established that they need no longer be seeded in order to make a stand. Native grasses and plants commonly include, therefore, prairie grasses, redtop, bluegrass, and white clover. A very small proportion of the principal crops is sold for cash. It is estimated that 80 percent of the corn, oats, and barley is

consumed on the farms and about 20 percent is sold on the outside markets. Most of the hay is used on the farms, but a small proportion is baled and shipped to market.

When first settled this county was almost treeless, but today nearly every homestead is surrounded by groves of trees and ornamental shrubs, which serve as windbreaks. Many farmers have planted additional groves separate from the homestead or have planted rows of trees along the roads. Some of the rougher or steeper strips of land are maintained more or less permanently in timber.

The use of mechanical corn pickers has increased greatly within the last few years. After the corn is harvested by mechanical pickers, the better farmers turn in cattle and hogs to pick up the shelled or missed grain that otherwise would be lost. According to estimates, 57 percent of the corn crop is harvested by mechanical pickers, 30 percent is picked by hand, and the rest is hogged off, cut for silage, or cut and shocked to be fed in the bundle, shredded, or husked by hand.

The application of lime prior to growing alfalfa or sweetclover is unnecessary on most of the soils. Field tests reveal an abundance of lime in nearly all of the soils, exceptions being Dickinson fine sandy loam and, in places, Clarion fine sandy loam. It is probable that better success with alfalfa and sweetclover would be obtained on Dickinson fine sandy loam if the soil were treated with from 2 to 3 tons of ground limestone to the acre. The Iowa Agricultural Experiment Station reports favorable responses of crops to superphosphate on Clarion, Marshall, and Webster soils in other counties. An increase in yields is reported after the use of barnyard manure on all cultivated soils in this county.

Several crop rotations are reported, of which the following are most commonly used: A 4-year rotation program, used by about 30 percent of the farmers, of corn, corn, oats, and clover; a rotation used by 25 percent, alternating corn and oats; a 3-year rotation, used by 25 percent, of corn, oats, and clover; and a 3-year rotation, used by 10 percent, of corn, corn, and oats.

Most farms are well equipped with modern farm machinery. On most of the larger farms there are one or more tractors and tractor plows, a tractor disk, tractor cultivator, corn picker, binder, mower, four-row corn planter, grain drill, corn elevator, manure spreader, side-delivery rake, hay loader, wagons, one- and two-row riding cultivators, and generally a cream separator. On most of the smaller farms the equipment is as complete, but horse-drawn machinery generally is used instead of the tractor equipment.

Erosion is not so serious on most of the soils in Osceola County as it is in many other counties in the State. The land is, for the most part, nearly flat, gently undulating, or gently sloping. The surface soils are very deep, contain considerable organic matter, and have predominantly loose finely granular structure near the surface with a more or less subangular nut structure in the subsurface layer. Such features result in highly permeable soils and lessen the destructive effects of erosion. A little sheet erosion and some gullying, however, have occurred on the long, very gentle slopes of Marshall silty clay loam, till-substratum phase, and on the more sloping areas

of Clarion loam and Marshall silty clay loam. Severe sheet erosion and gullying have occurred, in places, on Dickinson fine sandy loam, Clarion fine sandy loam, and Clarion loam, rolling phase.

Ordinarily the farmers complete as much of their plowing as possible in the fall. The amount of land plowed depends on the acreage in oats and meadow at the time and on the length of time during which the plowing can be done. Most of the old hay lands and plowable pastures that are to be turned back into cultivation are plowed in the fall, as well as grain fields that are not seeded to hay for the following season and other fields from which the crops have been removed.

DRAINAGE

Natural drainage may be classed as fair to slow on the greater part of both the uplands and the lowlands, and as good to excessive over only a small proportion of the county. With the exception of Dickinson fine sandy loam, Clarion fine sandy loam, and Clarion loam, rolling phase, none of the soils is adequately drained without the provision of direct or indirect artificial drainage. Artificial drainage of Marshall silty clay loam is largely indirect, as it has been effected by improving the drainage of adjoining soil areas by tiling. On the more undulating or sloping areas, such as those in the vicinity of Ashton, natural drainage of Marshall silty clay loam is sufficient and no artificial drainage is needed; but even here most of the associated soils require some improvement in drainage for successful cultivation. At least 75 percent of the farms, it is estimated, have some tile drainage, and from 20 to 25 percent of the total area is tillable only because of direct artificial drainage. Grading the roads throughout the county has improved surface drainage and to some extent internal drainage of the uplands, in both the loess and the drift areas, especially where the land is nearly level.

Because of the flat or nearly level surface of Marcus silty clay loam, the artificial drainage provided on most of it is not adequate for good yields of crops except in seasons with average or below average precipitation. This statement also applies, though to less extent, to Marshall silty clay loam, till-substratum phase, Clarion silty clay loam, Benoit silty clay loam, and the flatter, more slowly drained areas of Hancock silty clay loam. The Webster soils, Afton silty clay loam, muck, and most of Lamoure silty clay loam require artificial drainage before they can be satisfactorily cultivated. Areas of Afton silty clay loam are tile drained primarily for the purpose of facilitating tillage operations on surrounding soils rather than for the purpose of recovering the Afton soil for cultivation. When adequately drained, however, the productivity of the Afton soil approximates that of the associated soils. Drainage of Lamoure silty clay loam generally is improved by straightening the main channels and by extending lateral ditches out to the sides, so as to take care of the incoming waters from intermittent drains. Seepage at the base of slopes is best cared for by tiling along the base and leading the water into the lateral ditches or directly into the main channels.

PRODUCTIVITY RATINGS

Comparative ratings of the soil types according to their productive capacities for the important crops of the general region are given in table 6.

TABLE 6.—*Productivity ratings of soils in Osceola County, Iowa*

Soil [1]	Crop productivity index [2] for—							General productivity grade	Land classification [5]
	Corn	Oats	Barley	Clover and timothy	Alfalfa		Pasture [3]		
					With lime	Without lime			
Marcus silty clay loam, drained	95	95	90	95	100	95	95	1	Excellent cropland.
Marshall silty clay loam	95	95	90	95	95	90	95		
Marshall silty clay loam, till-substratum phase.	90	90	90	95	100	90	95		
Webster loam, drained	90	90	90	90	95	90	95		
Clarion silty clay loam	90	90	85	90	95	90	95		
Webster silty clay loam, drained	90	80	80	95	90	90	100		
Afton silty clay loam, drained	85	80	80	95	90	85	100	2	Good cropland.
Clarion loam	85	90	90	90	85	80	90		
Fargo silty clay loam, drained	75	70	65	85	75	70	85	3	Fair cropland.
Hancock silty clay loam, drained	75	70	70	80	70	70	75		
Lamoure silty clay loam, drained	70	60	60	85	70	70	85		
Webster silty clay loam, mucky phase, drained.	80	50	50	90	------	------	90		
Benoit silty clay loam, drained	65	60	60	80	------	------	75	4	
Clarion loam, rolling phase	60	60	60	60	65	------	70		
Clarion fine sandy loam	50	55	55	35	50	------	35		
Marcus silty clay loam, undrained	50	------	------	50	------	------	100	5	
Webster loam, undrained	40	------	------	40	------	------	95	6	
Benoit silty clay loam, undrained	30	------	------	35	------	------	75	7	Fair to poor cropland
Hancock silty clay loam, undrained.	30	------	------	30	------	------	75		
Dickinson fine sandy loam	35	40	40	30	30	------	20		
Muck, drained	30	------	------	60	------	------	20	8	Poor cropland.
Sioux fine sandy loam	30	30	30	25	20	------	20		
Afton silty clay loam, undrained	------	------	------	------	------	------	100	9	Pasture land.
Webster silty clay loam, undrained.	------	------	------	------	------	------	100		
Fargo silty clay loam, undrained	------	------	------	------	------	------	90		
Lamoure silty clay loam, undrained.	------	------	------	------	------	------	90		
Webster silty clay loam, mucky phase, undrained.	------	------	------	------	------	------	95		
Muck, undrained	------	------	------	------	------	------	70		

[1] The soils are listed in the approximate order of their general productivity under the average current practices, the most productive first.

[2] The soils of Osceola County are given indexes that indicate the approximate average production of each crop in percent of the standard of reference. The standard represents the approximate average yield obtained without use of amendments on the more extensive and better soil types of the regions in which the crop is most widely grown.

[3] Owing to limited data, these ratings are estimates.

[4] This classification indicates the comparative general productivity of the soils under dominant current practices. Refer to text for further explanation.

[5] This is a general classification to indicate the physical suitability of the soils for farming or grazing uses. In the actual delineation of land classes on a map other considerations, such as the pattern of distribution of soil types, are important.

The productivity of each soil for each crop is compared to a standard of 100, which represents the approximate average yield of the crop, obtained without the use of amendments, on the more extensive and better soils in the regions where the crop is grown principally. A rating of 25, for example, indicates that the soil type is one-fourth as productive for the specific crop as those soils that carry the standard index. Unusually productive soils or those given amendments, such as fertilizer, may yield larger crops than the standard and are rated above 100.

The following tabulation sets forth the acre yields that have been established as standards of 100. These yields represent the long-time average yields of crops of satisfactory quality on the better soils without the use of amendments.

Crop:		
Corn	bushels	50
Oats	do	50
Barley	do	40
Clover and timothy	tons	2
Alfalfa	do	4
Pasture	cow-acre-days[1]	100

[1] Cow-acre-days is a term used to express the carrying capacity of pasture land. As used here, it is the product of the number of animal units carried per acre multiplied by the number of days the animals are grazed without injury to the pasture. For example, the soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another soil able to support 1 animal unit per 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days the rating is 25.

The principal factors determining the productivity of land are climate, soil, slope, drainage, and management. These factors do not operate independently of one another, although occasionally one may entirely dominate the production for a single year. Fluctuations in crop yields from year to year, for instance, often are a direct reflection of the fluctuations in the climate.

Favorable combinations of the factors of production must exist if high yields of crops are to be obtained, and the nature of these favorable combinations is learned by experience and from experiments. Crop yields over a long period furnish the best available summation of the combined effect of the factors, and they are used as a basis for the establishment of productivity ratings wherever they are available. Crop yields by townships, both from the figures compiled by the State assessors and from the United States census, and yields from experimental plots and fields of the Iowa Agricultural Experiment Station have been used as sources of information and as guides in setting up the productivity ratings for the soils of this county. Many of the ratings, however, are still based on inductive estimates rather than on actual reported yields of crops, because of a lack of definite information. Nevertheless, it is thought that the ratings do give a fairly accurate picture of the relative productivities of the soils of this county.

Natural drainage is a limiting factor in crop production on many of the soil types. Many of the soils are rather heavy in texture throughout their entire profiles, so that internal drainage is slow, and the land ranges from very gently sloping to nearly flat over a large part of the county. Artificial improvement of drainage by means of tile is necessary for greatest crop production on a large number of soil types. Consequently, two ratings have been given for each of 10 soil types of the Marcus, Webster, Afton, Fargo, Hancock, Benoit, and Lamoure series, and for muck. One rating is given for areas that are adequately tiled and well drained, and another rating is given for the soil type with its natural poor drainage. Some areas, in which drainage has been improved to some extent, are not yet adequately tiled. The productivity of such areas will be between those of the poorly drained and the well-drained ones.

The soils are listed in the order of their general productivity under dominant current practices, and productivity grade numbers are

assigned in the column General productivity grade. The general productivity grade is based upon a weighted average [7] of the indexes for the various crops, using the approximate average acreage and value of the various crops in the county as a basis, except in the instance of soils upon which certain crops are not grown, as some of the poorly drained soils. If the weighted average falls between 90 and 100, the soil type is assigned a grade of 1; if it falls between 80 and 90, a grade of 2 is given, etc. Since it is difficult to measure mathematically either the exact significance of a crop in local agriculture or the importance and suitability of certain soils for particular crops, the weightings set up were used only as guides. Certain modifications dictated by personal judgment have been allowed in the general rating of the soils.

The column, Land classification, summarizes in a simple way the productivity and use capabilities of the various soils by placing them in a few groups on the basis of their relative suitability for farming and grazing.

Productivity-rating tables do not present the relative roles that soil types play in the agriculture of a county, but rather indicate the productive capacity of each individual soil. Total agricultural production of a soil type will depend on its extent and geographic distribution just as well as on its inherent productivity.

Economic considerations have played no part in determining the productivity indexes, which refer only to the inherent productivity of the soil for each crop or group of crops. The indexes, therefore, cannot be interpreted into land values, except in a very general way. The value of land depends on distance from market, dependability of production from year to year, the relative prices of farm products. and a number of other factors, in addition to the productivity of the soil.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of environment acting upon the soil materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent soil material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the relief, or lay of the land, which determines the local or internal climate of the soil, its drainage, moisture content, aeration, and susceptibility to erosion; (4) the biologic forces acting upon the soil material, that is, the plants and animals living upon and in it; and (5) the length of time the climatic and biologic forces have acted on the soil material.

The normally developed soils of this county apparently belong to that soil group to which Marbut (*6*) has given the name Prairie soils, though they have many characteristics of the Chernozems. The Prairie soils may be briefly defined as dark-colored soils in which calcium carbonate has not accumulated in the solum at maturity, whereas the Chernozems typically have a distinct horizon of lime

[7] The weights in percentage given each crop index to arrive at the general productivity grade were (with a few exceptions) as follows: Corn, 45; oats, 30; clover and timothy hay, 5; pasture, 20. The acreages of barley, alfalfa, and soybeans are all small, the total combined acreage of the latter two crops amounting to only a fraction of 1 percent of cropland. The acreage of barley was combined with that of oats in the establishment of the relative weightings to be given the different crop indexes in obtaining a general productivity grade.

accumulation. This county is in a transitional zone and not more than 30 miles east of the line that theoretically separates the region where lime accumulates in the soils from that in which it does not accumulate. Some accumulation of calcium carbonate apparently does occur here in localities especially favorable for this process. At least, it can be said that precipitation has been sufficient to leach the carbonates, over the greater part of the county, only to a depth ranging from 18 to 40 inches. Below this depth calcium carbonate commonly is abundant.

All the soils are developed directly or indirectly from three unconsolidated Pleistocene deposits, namely, Iowan drift, Peorian loess, and Wisconsin drift. The older glacial drift now assigned by geologists to the Iowan stage (*3*) was deposited over a surface having but slight relief. The topographic features of the older plain were not greatly changed by the Iowan drift. Much of the surface of the Iowan drift was later covered by a mantle of silty material called Peorian loess. This loess now constitutes the parent material of the soils of the southwestern half of the county. The loess mantle is thin, ranging from 24 to 48 inches in thickness over the greater part of its area, and probably nowhere exceeds 60 inches. Toward its eastern limits the loess is so thin that the underlying till forms the parent material of the lower part of the solum and in places approaches the surface. In a few small areas within the loess-covered section, the loess has been entirely removed and a soil has developed from the Iowan till. These areas are indicated on the soil map, in the western part of the county, as Clarion loam.

The second drift mantle was deposited over nearly one-half of the county when a lobe of the Wisconsin ice sheet invaded the northeastern part. This drift consisted of a heterogeneous mass of coarse and fine materials. On the greater part of the drift, namely, the till plain, the loams and silty clay loams of the Clarion and the Webster series have developed. Comparatively small quantities of gravel and boulders are scattered over the surface and through the soil. On smaller areas of coarser drift, fine sandy loams of the Clarion and Dickinson series have formed. The depth to which oxidation and leaching have proceeded in the Wisconsin drift since its deposition depends on such local factors as the texture of the material and the character of the relief. The average depth to which the carbonates have been leached is probably about 30 inches. Leaching has reached the greatest depth in the coarse sandy drift from which Dickinson fine sandy loam has developed.

The Peorian loess was deeply covered by Wisconsin drift, but this silty material, picked up and redeposited by the wind, has entered into the composition of some soils developed principally from the drift. The shifting of silty material has taken place mainly in a belt along the western extension of the Wisconsin drift, where the admixture of wind-borne silts has modified the surface soils of Clarion silty clay loam and, probably of Webster loam.

The native vegetation at the time the region was settled consisted mainly of grasses of the well-drained prairie and, on the poorly drained areas, of a rank growth of water-loving grasses, weeds, and sedges. A fringe of trees around several lakes and marshes had not produced any noticeable change in the soils.

The drainage pattern is dendritic in form, but immature and not well developed. Natural drainage is slow, both externally and internally, on more than 50 percent of the area; fairly free to free externally and slow internally on 25 percent; good to free, both externally and internally, on 15 percent; and on the remaining area either the external or the internal drainage is slow and the other good to excessive.

The soils fall into two general groups, which can be established on the basis of characteristics due to differences in drainage conditions during their development. Marshall silty clay loam is representative of a normal soil developed on Peorian loess. Following is a description of a representative profile of this soil observed in the northeastern part of sec. 31, T. 99 N., R. 41 W.:

0 to 5 inches, very dark grayish-brown or nearly black very finely granular mellow silty clay loam containing a high proportion of organic matter. The reaction is slightly acid. The material is very porous.

5 to 12 inches, very dark grayish-brown or nearly black silty clay loam, which breaks readily into fairly firm small or medium-small subangular granules. The cut surface is definitely dark grayish brown, but the broken surface, which exposes the surface of the granules, is nearly black under optimum to wet moisture conditions, indicating that more of the organic matter occurs as a thin covering on the granules than is distributed throughout the internal part of the fragment. In place the porosity is somewhat less than in the layer above, but when crushed or loosened by plowing the difference is imperceptible. Under optimum to slightly wet conditions, the material becomes somewhat plastic with increased pressure and slightly sticky when wet. The reaction is acid.

12 to 22 inches, material that is similar in texture, structure, and color to the overlying material, except that the cut surface is more brown, indicating a smaller accumulation of organic matter within the granules at this depth than in those nearer the surface.

22 to 31 inches, a gradual transition from the dark layers above to the brownish-yellow layers below. The texture is very heavy silt loam or silty clay loam. The color on the broken surface is dark grayish brown, but the cut surface appears light olive brown or grayish olive yellow. The structure is still granular, but the granules are very soft and are readily broken into a friable loose rounded fine-crumb structure. Many fine vertical pores are present in this layer and in the underlying layers of loess, generally increasing in number with depth, but the vertical pores commonly do not penetrate into the underlying glacial till. The material has a slightly acid reaction.

31 to 40 inches, dark-yellow or yellowish-brown silty clay loam with a fairly loose massive structure, which breaks very readily into a fine-crumb structure. The color appears uniform from a little distance, but close examination reveals a variation from bright yellow to brownish yellow. The reaction is slightly acid.

40 to 52 inches, material that represents little change from the material above in texture and structure but has slightly looser consistence. The brown color is broken by faint streaks of light-gray finely divided calcium carbonate, which increase with depth. Effervescence with acid is mild at a depth of 40 inches and strong at a depth of 52 inches. Some small specks or mottlings of dark yellow and rusty brown appear in the lower part of this layer.

52 to 55 inches, a thin layer of light yellowish-gray calcareous silty clay loam, intermixed with small to large pebbles of the glacial till. Most of the pebbles, and in places small cobblestones, appear to rest on the surface or project above the surface of the underlying glacial till, with the loess material filling the intervening spaces.

55 to 68 inches, fairly bright brownish-yellow sand, which is somewhat stratified, contains considerable gravel in places, includes some finer-textured materials such as fine sands, silt, and clay distributed more or less evenly throughout. The material in this layer is strongly calcareous.

68 inches +, yellowish-brown or brownish-yellow heavy gritty clay glacial till, mottled with yellow, brown, and some bluish gray. Granitic, porphyritic, and limestone pebbles are numerous in this material. This layer continues downward to a depth of many feet with very little change except that the bluish-gray color increases until the yellow and brown practically disappear.

Other soils having the normal profile but developed from till are Clarion loam, Clarion silty clay loam, and Clarion fine sandy loam of the rolling uplands. Hancock silty clay loam and Sioux fine sandy loam of the terraces also are well-drained soils.

The soils of the nearly level divides having restricted drainage either externally or internally, and in many places both, are not developed under normal conditions and must therefore be regarded as intrazonal. The most extensive soils of this group are Webster silty clay loam and Webster loam, which are developed from till and are hydromorphic associates of the well-drained Clarion soils. Following is a description of a profile of Webster silty clay loam observed 2 miles northeast of Cloverdale:

0 to 2 inches, black mellow very finely granular silty clay loam high in organic matter. This layer is completely filled with small roots and coarser rootstocks. The material is neutral in reaction.

2 to 12 inches, black heavy silty clay loam. When the soil is exposed to the air and dried, the blocky structure apparent in plowed fields crumbles into subangular to angular fragments. The breakage lines are not very distinct when the soil is moist but are sufficiently well formed to allow fracture along those lines as the mass shrinks in drying. Under optimum moisture or slightly drier conditions the granules are crushed readily to a mass that appears somewhat grayer than the granular mass. When moderately or decidedly wet, the mass is slightly to fairly sticky and is plastic. The reaction is neutral.

12 to 18 inches, material similar in color to that in the layer above but more massive in structure, somewhat more compact in place, and slightly heavier in texture. It has an alkaline reaction.

18 to 22 inches, a transitional layer from the dark-colored surface layer to the light yellowish-gray heavy plastic clay subsoil. The material is calcareous.

22 to 30 inches, light yellowish-gray heavy somewhat gritty clay stained or streaked with gray. It contains finely divided calcium carbonate.

30 to 40 inches, gray heavy gritty clay, stained or mottled with yellow and brown, alternating with layers of bluish-gray clay that generally contains gravel and boulders.

Boulders are present at the surface in places but more commonly occur in the lower part of the profile, just above and within the till.

Marcus silty clay loam, developed from loess, and Fargo silty clay loam, developed from terrace material, have developed under deficient drainage, and their profiles resemble those of the Webster soils in many respects.

The soils of the Afton series have developed from loess under drainage even less favorable to normal development than those giving rise to the Webster soils. These soils occupy shallow valleys and basinlike depressions at the heads of drainageways. The rainfall on the areas is augmented by run-off and seepage from the higher land. Following is a description of a profile of Afton silty clay loam as observed in the southwestern part of sec. 16, T. 99 N., R. 42 W.

0 to 4 inches, black very mellow finely granular slightly acid silty clay loam or light silty clay, containing a very high proportion of organic matter.

4 to 12 inches, very dark brownish-gray or nearly black light silty clay or silty clay loam. Under moist or wet conditions the structure appears massive, but as the soil material becomes moderately dry, natural break-

age lines appear and the mass breaks up into moderately fine structure particles. This layer contains less organic matter than the layer above. It puddles more readily, but if plowed under optimum moisture conditions the upper part of this layer, together with the surface layer, develops into a mellow seedbed. The reaction is neutral.

12 to 24 inches, very dark gray or medium dark gray silty clay loam, which is massive in structure and appears somewhat stratified in places. The material dries hard and becomes intractable. It is neutral to slightly calcareous in reaction. A slight effervescence with acid is indicated in the lower part. In places this layer appears to have a slight glei development.

24 to 28 inches, pale yellowish-gray silt loam, which is rather massive in structure and fairly compact in place. It dries hard but not so hard as the material above. Under optimum moisture conditions it breaks fairly readily into irregular fragments or coarse granules, but the breakage lines, if present, are indistinct. The material is calcareous.

28 to 36 inches, light yellowish-gray highly calcareous heavy loam or light silty clay loam. The mass appears somewhat like marl. More or less mottling of brown occurs in the lower part. Some gritty materials are present in places immediately above the drift.

36 to 42 inches, weathered glacial till material similar in color to that of the layer above except that the mottlings are somewhat more pronounced. It does not break so readily into a crumbly mass as the material above.

The alluvial deposits are composed almost entirely of materials brought down from areas of loess and glacial drift. Two soils have developed on the gravelly materials that compose the older terraces; namely, Sioux fine sandy loam on the well-drained terraces and Benoit silty clay loam on the poorly drained terraces, the latter generally occupying the lower terraces. These soils are most extensive along the Ocheyedan River. The character of soils on the heavy materials also has been determined largely by drainage conditions. Hancock silty clay loam, extensively developed along Otter Creek and its tributaries, is a well-drained soil, whereas Fargo silty clay loam has developed under conditions of imperfect drainage.

Table 7 gives the results of mechanical analyses of several soils of this county, made in the laboratories of the Bureau of Chemistry and Soils.

TABLE 7.—*Mechanical analyses*[1] *of 3 soils developed from Peorian loess and 2 soils developed mainly from Wisconsin glacial till in Osceola County, Iowa*

Soil type and sample No.	Depth	Fine gravel (2–1 mm.)	Coarse sand (1–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.1 mm.)	Very fine sand (0.1–0.05 mm.)
Marshall silty clay loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
338894	0– 5	0.3	0.3	0.4	0.8	1.9
338895	5–12	.1	.2	.2	.5	1.7
338896	12–22	.1	.2	.3	.6	1.9
338897	22–31	.0	.1	.2	.5	1.9
338898	31–40	.0	.1	.1	.4	3.7
338899	40–52	.1	.4	.4	1.1	10.3
3388100	52–55	.9	3.0	2.9	5.0	11.1
3388101	55–68	3.9	16.9	19.1	28.4	7.2
3388102	68–73	2.9	4.8	4.8	10.7	9.0
Marcus silty clay loam:						
338884	0– 5	.3	.5	.7	1.9	3.3
338885	5–14	.0	.5	.6	1.2	2.2
338886	14–20	.1	.5	.5	1.0	2.3
338887	20–24	.1	.6	.5	.9	2.5
338888	24–32	.1	.3	.4	1.0	4.3
338889	32–41	.4	.9	.9	1.8	6.4
338890	41–43	1.4	5.0	7.2	12.3	10.1
338891	43–47	1.7	4.7	5.4	11.4	9.0
338892	47–58	2.5	4.3	4.7	10.6	9.5
338893	58–72	3.2	4.8	4.8	10.4	9.2

[1] Percentage calculations on organic-free basis.

TABLE 7.—*Mechanical analyses of 3 soils developed from Peorian loess and 2 soils developed mainly from Wisconsin glacial till in Osceola County, Iowa*—Con.

Soil type and sample No.	Depth	Fine gravel (2–1 mm.)	Coarse sand (1–0.5 mm.)	Medium sand (0.5–0.25 mm.)	Fine sand (0.25–0.1 mm.)	Very fine sand (0.1–0.05 mm.)
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Afton silty clay loam:						
338810	0–4	.4	.5	.4	1.2	2.5
338810	4–12	.1	.3	.5	.9	3.4
338810	12–24	.1	.3	.4	.8	3.1
338810	24–28	.1	.3	.5	1.0	7.2
338810	28–36	.5	.1	.1	4.0	7.4
338810	36–42+	1.4	4.3	4.3	6.2	9.1
Clarion loam:						
338842	0–2	1.6	3.8	4.8	13.1	9.5
338843	2–14	2.4	5.5	6.3	16.7	10.5
338844	14–21	2.2	4.6	5.5	14.9	10.3
338845	21–30	1.7	4.2	4.7	12.7	10.0
338846	30–40	2.3	4.8	4.9	11.9	9.7
338847	40–64	2.5	5.0	4.8	11.5	8.6
Webster silty clay loam:						
338835	0–1½	.9	1.2	2.1	6.9	4.7
338836	1½–15	.4	1.6	1.9	4.8	4.5
338837	15–21	1.2	2.6	2.6	7.3	5.2
338838	21–28	2.6	3.8	3.6	8.9	6.4
338839	28–34	1.4	2.9	3.7	8.9	7.3
338840	34–41	2.8	4.6	4.4	12.1	8.3
338841	41–52	3.1	5.9	5.6	12.4	9.5

Soil type and sample No.	Depth	Silt (0.05–0.002 mm.)	Clay (0.002 mm.)	Organic matter by H_2O_2	Mineral matter dissolved by H_2O_2	Clay (0.005 mm.)[1]
	Inches	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Marshall silty clay loam:						
338804	0–5	60.4	35.9	7.0	0.8	41.8
338805	5–12	60.2	37.1	5.1	.6	43.7
338806	12–22	59.5	37.5	4.1	.6	43.4
338807	22–31	65.5	31.7	1.9	.4	40.9
338808	31–40	67.1	28.6	.6	.2	35.7
338809	40–52	65.1	22.6	.5	.2	28.2
3388100	52–55	56.5	20.6	.4	.1	26.7
3388101	55–68	11.6	12.9	.2	.2	16.8
3388102	68–73	42.2	25.6	.2	.2	34.5
Marcus silty clay loam:						
338884	0–5	58.1	35.2	6.9	.4	42.1
338885	5–14	59.5	36.0	5.0	.4	43.9
338886	14–20	59.2	36.4	2.8	.2	43.7
338887	20–24	60.1	35.3	2.0	.3	41.6
338888	24–32	63.4	30.4	.3	.2	36.5
338889	32–41	65.3	24.3	.2	.2	29.9
338890	41–43	42.5	21.5	.2	.2	26.0
338891	43–47	41.4	26.4	.2	.2	34.3
338892	47–58	42.7	25.7	.2	.2	34.4
338893	58–72	42.1	25.5	.1	.2	33.8
Afton silty clay loam:						
338810	0–4	61.2	33.9	10.5	.9	42.2
338810	4–12	63.4	31.4	3.0	.2	36.4
338810	12–24	60.3	35.0	.7	.3	39.9
338810	24–28	62.0	28.9	.4	.2	33.9
338810	28–36	60.2	27.7	.6	.2	33.6
338810	36–42+	48.6	26.1	.3	.2	30.3
Clarion loam:						
338842	0–2	40.2	27.0	7.9	.4	33.0
338843	2–14	32.0	26.7	4.0	.2	31.3
338844	14–21	32.3	30.2	1.2	.4	37.1
338845	21–30	37.0	29.7	.6	.3	40.3
338846	30–40	36.6	29.8	.4	.2	40.7
338847	40–64	37.4	30.2	.2	.4	41.6
Webster silty clay loam						
338835	0–1½	47.6	36.6	8.2	.8	44.3
338836	1½–15	54.4	32.5	4.5	.2	46.4
338837	15–21	41.9	39.1	.8	.3	47.7
338838	21–28	35.4	39.3	.5	.3	49.0
338839	28–34	34.9	40.9	.3	.2	51.7
338840	34–41	34.9	32.9	.2	.2	42.3
338841	41–52	34.3	29.2	.1	.2	37.2

[1] Older classification for clay not included in total.

Table 8 shows the results of pH determinations of several soils in the county. These values were determined in the laboratories of the Bureau of Chemistry and Soils by E. H. Bailey, using the hydrogen-electrode method.

TABLE 8.—*pH determinations on several soil profiles from Osceola County, Iowa*

Soil type and sample No.	Depth	pH
Dickinson fine sandy loam	*Inches*	
338823	0 - 2	7.0
338824	2 - 6	6 5
338825	6 -14	5.9
338826	14 -45+	6.3
Sioux fine sandy loam.		
338831	0 - 8	6.7
338832	8 -15	5.8
338833	15 -22	5.8
338834	22 -45+	8.2
Webster silty clay loam:		
338835	0 - 1½	7.7
338836	1½-15	6.3
338837	15 -21	7.9
338838	21 -28	8.0
338839	28 -34	8.1
338840	34 -41	8.0
338841	41 -52+	8.0
Clarion loam:		
338842	0 - 2	7.5
338843	2 -14	6.5
338844	14 -21	8 0
338845	21 -30	8 2
338846	30 -40	8.2
338847	40 -64	8.1
Clarion fine sandy loam:		
338848	0 -10	6.5
338849	10 -18	5.6
338850	18 -30	6.1
338851	30 -50	8.2
Clarion silty clay loam:		
338852	0 - 1	7.8
338853	1 - 6	6.2
Clarion silty clay loam—contd.	*Inches*	
338854	6-14	6.2
338855	14-22	6 2
338856	22-30	8 3
338857	30-48	8.2
Marcus silty clay loam:		
338884	0- 5	7.0
338885	5-14	6.4
338886	14-20	7.0
338887	20-24	7 5
338888	24-32	7 8
338889	32-41	8.1
338890	41-43	8.1
338891	43-47	8.2
338892	47-58	8.3
338893	58-72	8.4
Marshall silty clay loam		
338894	0- 5	6 4
338895	5-12	5 9
338896	12-22	5 6
338897	22-31	5 8
338898	31-40	6.4
338899	40-52	8.1
3388100	52-55	8 2
3388101	55-68	8.2
3388102	68-73	8 1
Afton silty clay loam		
3388103	0- 4	6.3
3388104	4-12	6 8
3388105	12-24	7.8
3388106	24-28	8.3
3388107	28-36	8 3
3388108	36-42+	8.2

SUMMARY

Osceola is one of Iowa's northwestern counties. Its elevation above sea level ranges from about 1,400 to 1,675 feet, and it includes the highest points within the State. The county lies within the drainage basin of the Missouri River, but the county itself is drained toward the south and west through Otter Creek and the Little Rock River and their branches and toward the southeast through the Ocheyedan River and its tributaries.

The first settlers arrived in the early spring of 1871, a few coming from neighboring counties and others from counties farther east and from other States, mainly Wisconsin and Illinois. The first railroad, the Sioux City & St. Paul Railroad, was completed through the county in 1872. Settlement was rapid until the grasshoppers came in the spring of 1873, after which the population increased only slightly until 1880, when the attacks of the grasshoppers stopped.

Natural drainage, both external and internal, is comparatively slow over the greater part of the county, owing to the relatively slight relief and the moderately heavy soil textures. In the more rolling morainic areas in the northeast and the more sloping areas bordering some of the major stream valleys, however, drainage ranges from good to excessive, owing to the undulating or sloping relief

and the coarser textures of the subsoils. The soils of the southwestern half are derived largely from loess and those of the northeastern half mainly from Wisconsin glacial till. Both parent materials are highly calcareous. The soils were developed under grass vegetation in a humid temperate climate and are characterized by deep surface soils, which are very dark grayish brown or black, except the sandy loams, which are dark brown or very dark grayish brown. The subsoils vary from yellowish brown to gray. The soils have been classified under 11 soil series, separated into 14 types and 3 phases, in addition to muck, an organic soil. Nearly all of the soils can be classed as tillable, although the majority have required some artificial drainage to make them suitable for cultivation, especially with improved farm machinery. They are admirably suited to the production of corn, small grains, hay, and other general farm crops suited to a humid temperate climate, as well as very productive of native and introduced grasses and plants for pasturage.

The early agriculture and the present one are similar in respect to the production of general farm crops and the raising of cattle, hogs, and poultry; but wheat, which was one of the major crops and the main cash crop from the early years until after 1900, has become a minor crop since 1900 and has not been replaced by another cash crop. The present farm income is derived largely from the sale of cattle, hogs, dairy products, and poultry. The principal crops are, in order of their importance, corn, oats, hay, and barley. About 80 percent of the feed crops is used on the farms, and about 20 percent is sold to outside markets. Alfalfa has become an important hay crop and is grown on more than one-third of the hay acreage.

Erosion is not a serious problem on most of the soils, because of the predominantly favorable relief and soil structure. Some sheet erosion and gullying have occurred on the areas with gentle relief, however, and have been severe in the few rolling to fairly steeply sloping areas. In these latter areas proper farm practices to correct existing damage and prevent further erosion should be followed.

LITERATURE CITED

(1) GANNETT, HENRY.
1906. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bull. 274, ed. 4, 1072 pp.

(2) IOWA EXECUTIVE COUNCIL.
1874. THE CENSUS OF IOWA AS RETURNED IN THE YEAR 1873, SHOWING, IN DETAIL, THE POPULATION, AGRICULTURAL STATISTICS, AND OTHER ITEMS OF INTEREST. 156 pp. Des Moines.

(3) KAY, GEORGE F., and APPEL, EARL T.
1929. THE PRE-ILLINOIAN PLEISTOCENE GEOLOGY OF IOWA. Iowa Geol. Survey (1928) 34: [1]–304, illus.

(4) LEES, JAMES H.
1927. ALTITUDES IN IOWA. Iowa Geol. Survey (1925–26) 32: [363]–549, illus.

(5) MACBRIDE, T. H.
1900. GEOLOGY OF OSCEOLA AND DICKINSON COUNTIES. Iowa Geol. Survey (1899) 10: [185]–239, illus.

(6) MARBUT, C. F.
1935. SOILS OF THE UNITED STATES. U. S. Dept. Agr., Atlas of American Agriculture, pt. 3, Advance Sheets No. 8, 98 pp., illus.

(7) PERKINS, D. A. W.
1892. HISTORY OF OSCEOLA COUNTY. 269 pp., illus. Sioux Falls, S. Dak.

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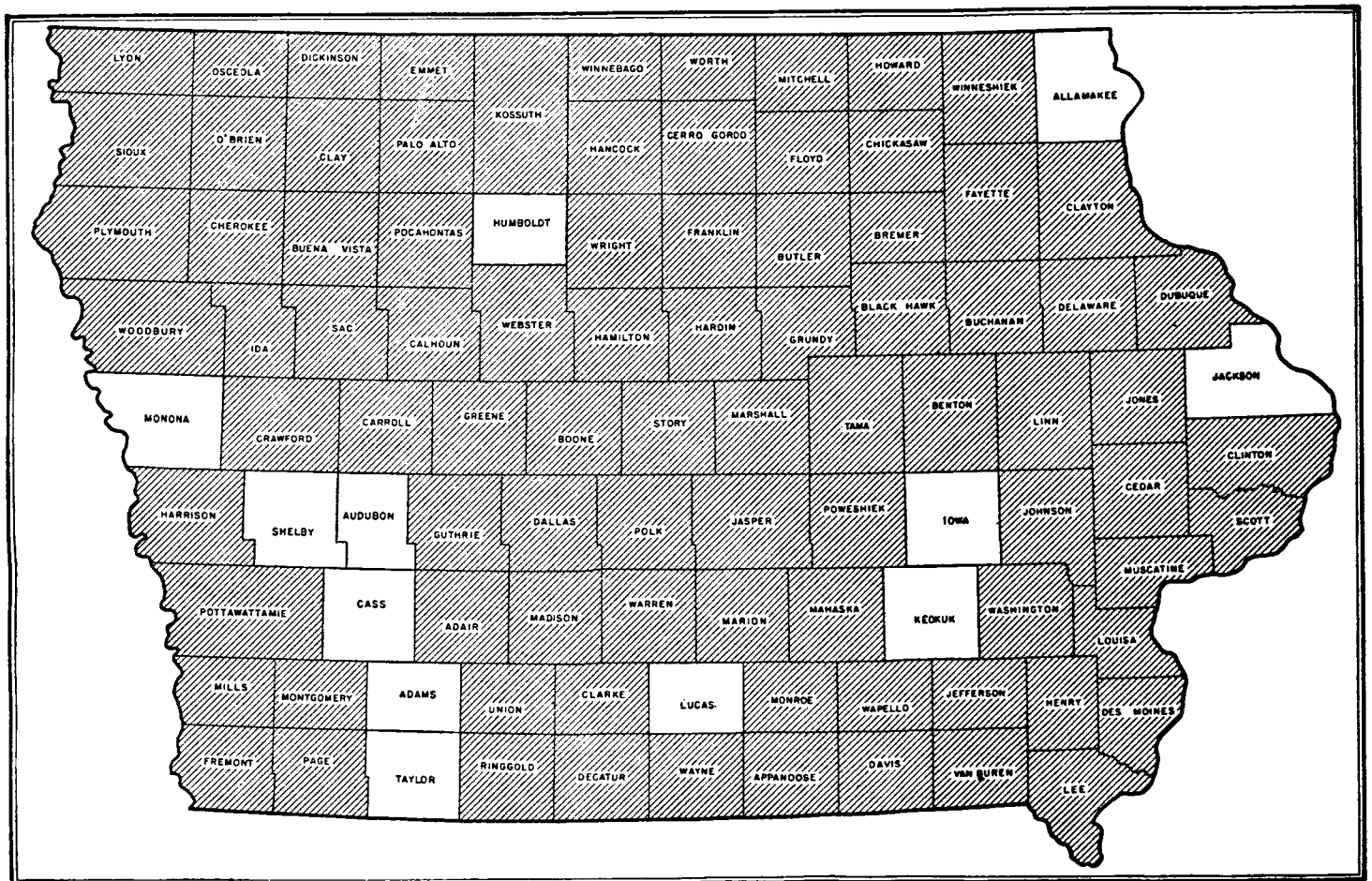

Areas surveyed in Iowa shown by shading

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