Series 1935, No. 13 Issued January 1940

Soil Survey

Cerro Gordo County
Iowa

By
J. A. ELWELL, in Charge
H. L. DEAN, FOSTER RUDOLPH, and E. W. TIGGES
Iowa Agricultural Experiment Station

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

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By J. A. ELWELL, in Charge, H. L. DEAN, FOSTER RUDOLPH, and E. W. TIGGES, Iowa Agricultural Experiment Station

Area inspected by T. D. RICE, Inspector, District 3, Soil Survey Division,[1] Bureau of Chemistry and Soils, United States Department of Agriculture

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COUNTY SURVEYED

Cerro Gordo County is in the north-central part of Iowa in the second tier of counties south of the Minnesota-Iowa State line (fig. 1). Mason City, the county seat, is about 140 miles south of St. Paul, 350 miles northwest of Chicago, and 120 miles north of Des Moines. The county is square, comprising 16 townships of 36 square miles each, and has a total land area of 567 square miles, or 362,880 acres. Clear Lake, which covers an area of about 5½ square miles in the western part of the county, is the third largest lake in Iowa.

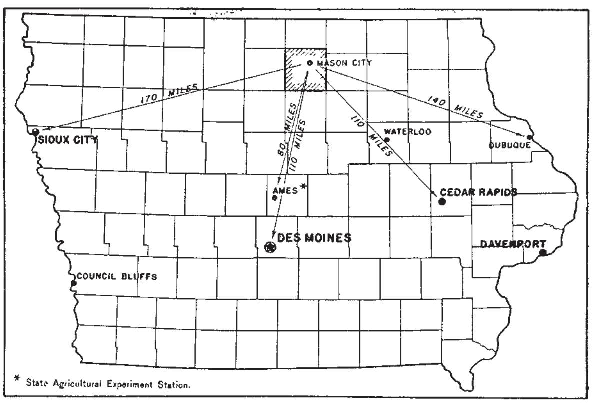

FIGURE 1.—Sketch map showing location of Cerro Gordo County, Iowa.

The land area of the county may be roughly divided into two parts; the first includes the westernmost tier of townships and has a somewhat uneven surface, and the second includes the rest of the county to the east and has a uniformly undulating surface. The relief of Grant Township, characterized by an intricate network of narrow depressions winding among clusters of small round-crested hummocks, is more pronounced than that of any other township. In contrast, the relief of the western half of Union Township and parts

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

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of Grimes Township is very gently undulating. The relief in the other townships in the westernmost tier is intermediate between these two extremes. The land surface of the eastern three-fourths of the county comprises broad-crested ridges, long slopes, and broad depressions of definite trend, which do not form the intricate pattern of those in the western part. Considerable areas are almost level. The larger of these are in the extreme northeastern part of Falls Township, the eastern half of Lake Township, the northeastern quarter of Owen Township, and in strips along Lime, Calmus, Willow, and Beaverdam Creeks. The uplands immediately bordering the main streams are gently rolling, except where the limestone outcrops and the slopes are steep. The small total area of more rolling land occurs only in narrow strips adjacent to the larger streams.

The elevation throughout the county ranges from about 1,100 to nearly 1,300 feet above sea level. The general slope is from northwest to southeast, parallel to the direction of the main drainageways. The western part of Union Township slopes slightly to the west, and the northern part of Grant Township slightly to the northeast. The rest of the western part follows the general slope to the southeast.

The Shell Rock River and its tributary, Lime Creek, are the largest streams. The river occupies a very narrow flood plain closely hemmed in by uplands having a limestone substratum. The flood plain itself has limestone underlying the alluvial deposits, which in many places are only 2 or 3 feet thick. The valley walls rise from this flood plain rather steeply to upland crests, which have almost the same elevation as the bordering plain. In the vicinity of Plymouth, south of Rock Falls, near the point where the river leaves the county, the valley widens to include terrace benches forming the wall of the narrow alluvial flood plain. The upland drainageways tributary to the river extend but a mile or two on each side of it; nevertheless they furnish good natural drainage to this narrow watershed. At the heads of drainageways in the broader upland depressions and in the slightly depressed back benchlands, it is necessary to improve the natural drainage by ditching and tiling.

In its lower reaches, Lime Creek has a flood plain ranging from one-fourth to one-half mile in width, with terrace benchlands 2 miles wide throughout much of the valley, although it carries a flow of water but little greater than that of the Shell Rock River with its smaller valley. In the vicinity of Mason City, Lime Creek is hemmed in by uplands having a limestone substratum, as is the river. Throughout much of its extent, however, the alluvial flood plain of the creek has an alluvial soil mantle ranging from 3 to 4 feet in thickness over the limestone substratum. Blair, Calmus, and Willow Creeks are fair-sized tributaries, which bring the entire northern half of the county west of the Shell Rock River into the drainage basin of Lime Creek. Willow Creek is the natural outlet of Clear Lake and the depressed areas north of this lake. At present the water in Clear Lake lies at a lower level than the mouth of its outlet, and the flow of Willow Creek is intermittent. In the drainage basins of these three tributaries, and north of Lime Creek proper, are considerable areas of back benchlands, broad upland depressions, and a few level upland plains, over which ditching and tiling are necessary, in order to supplement the naturally imperfect surface drainage. The upper reaches of Lime Creek, as it flows northeastward through Grant Township and out of the county, have a narrow flood plain; the areas of benchland are few and narrow, and tributaries extend only 1 mile from the main channel into the rolling uplands that border the valley. Here, the valley is in marked contrast to the valley occupied by Lime Creek farther east.

Coldwater and Beaverdam Creeks rise in the southern part of the county and, together with their tributaries, provide natural drainage, which is sufficient for most of the land along their lower courses. Tiling and ditching are necessary over considerable areas at the heads of these streams, on the edges of their drainage basins, and on the broader upland divides, depressed drainageways, and back benchlands within their basins. Beaverdam and Bailey Creeks head in the network of upland depressions in the westernmost tier of townships south of Clear Lake. In the vicinities of Swaledale and Thornton, respectively, the two streams traverse extensive benchlands, below which drainage channels branch out into a well-drained basin and finally join to form the West Fork Cedar River in Franklin County.

The flow of all the streams is slow, stream cutting is slight, and little soil material is transported. Lime Creek and the Shell Rock River are the only perennial streams. The broader valleys were carved by streams much larger than those that now occupy the channels, and the terrace benchlands of the valleys are deposits of the large load of sediments carried by these older streams. The former streams, which carried large loads of sediments, at times flowed from melting glacial ice that covered the county at different periods. The somewhat rougher relief of the westernmost tier of townships marks the edge of the last Wisconsin glaciation, and the smoother land of the rest of the county represents the plain left by the Iowan glaciation. No land forms resulting from the Kansan glaciation, which preceded the Iowan, now exist, but the gravel strata of the Lime Creek benchlands are of pre-Iowan age.

The first settlers in this county found an expansive prairie, with hardwood trees growing only along the larger streams and in a few places on the more uneven parts of the plain, especially in the hummocky areas in Grant Township. Practically all of the areas shown on the map as Lindley loam and many of those shown as Dodgeville soils supported a native tree growth of oaks, hickory, soft maple, aspen, and locust, with shrubs predominating over grass in the undergrowth. On the flood plains the vegetation consisted of cottonwood, boxelder, elm, ash, and walnut, with a mixed shrub and grass undergrowth. The scant supply of merchantable timber in this mixed hardwood growth has been cut, and at present few of the trees are large enough for any purpose except to supply a small local demand for fence posts and fuel. Groves have been planted for shelter and wood lots around nearly all of the farm building sites. Most of the groves are more than 35 years old and consist chiefly of cottonwood, boxelder, and maple, together with some conifers, such as cedar, spruce, white pine, and red pine.

The first settlements were made in 1852, at the present sites of Rock Falls and Mason City. The earliest settlers were from the older States and were mostly native-born Americans of Scandinavian, German, English, and Irish descent. After settlement had overcome the initial setbacks from opposition by the Indians, lands were rapidly taken up, and by the early sixties most of the land was claimed. According to an early State census of 1867, the county's population was 1,988, and less than 4,000 acres of the land remained unclaimed (*5*).[2]

The Federal census of 1930 gives the population of the county as 38,476, of which 31.5 percent is classed as rural, with a density of 21.4 persons a square mile. Only 8.3 percent of the population represents foreign-born persons, of whom Germans, Mexicans, Danes, Norwegians, Greeks, Russians, English, and Swedes are the most numerous, in the order named. The Mexicans have been brought in by the sugar-beet growers in recent years for the intensive labor required for the beet crop. The Greeks and Russians are not engaged in farming but are employed at Mason City, a railroad and industrial center with a population of 23,304. Clear Lake, with a population of 3,066, is a popular resort, and Rockwell, Plymouth, Thornton, Meservey, and Dougherty serve as trade centers for their agricultural communities.

During 1929 Cerro Gordo County had 57 manufacturing establishments, which employed 2,406 wage earners and paid $3,191,183 in wages. Among these are a beet-sugar factory, a packing plant, and seven dairy-products plants, which provide good local market facilities to the nearby farmers. Local clay, limestone, shale, and gravel deposits support two cement plants, two clay-works plants, a gravel company, and a stone company at Mason City. A second gravel company operates at Clear Lake. Although Mason City has become an industrial center, agriculture is still a very important enterprise in this county. Of 14,781 gainfully employed persons reported by the 1930 Federal census, 3,223 were engaged in agricultural occupations; 2,098 in wholesale and retail business; 1,035 in professions; 1,019 in clay, glass, and stone industries; 955 in meat-packing plants; 786 in railroad work; and 718 in building industries.

The larger terminal markets of St. Paul, Chicago, and Des Moines are reached conveniently from the 12 towns and 7 smaller shipping points along the 5 railway systems traversing the county—the Chicago & North Western Railway, the Chicago Great Western Railroad, the Chicago, Milwaukee, St. Paul & Pacific Railroad, the Chicago, Rock Island & Pacific Railway, and the Minneapolis & St. Louis Railroad, all which pass through Mason City. An electric railway connects Mason City and Clear Lake.

Improved all-weather highways reach all sections and connect the principal towns. United States Highway No. 65 is paved with concrete and crosses the county north and south through Mason City and Rockwell. It is a direct route to the terminal markets of St. Paul and Des Moines. United States Highway No. 18, a paved road, crosses the county east and west through Clear Lake and Mason City. A third paved road, a State highway, connects Mason City with Clear Lake. Almost one-half of the farms are directly on surfaced roads, and no farm is more than 3 or 4 miles distant from a gravel road. In the 1930 Federal census, 279 farms reported having autotrucks for transporting farm products to markets.

Cerro Gordo County affords excellent educational facilities. More than 100 elementary schools are accessible to the farms, and 9 high

[2] Italic numbers in parentheses prior to Literature Cited, p. 68.

schools are located in the towns serving the various sections of the county. A junior college and private business and trade schools are located at Mason City.

Rural mail routes and telephone lines provide excellent communication facilities to all sections. Modern living conditions can be had throughout the rural sections. In the 1930 Federal census report, telephones were reported on 1,597 farms, electric lights on 357 farms, and water piped to the houses on 291 farms.

CLIMATE

Cerro Gordo County has a continental climate, with the four seasons distinctly marked by different conditions of rainfall and temperature. The summers are consistently warm, with well-distributed rainfall, and the winters are cold, with snow covering the ground most of the season. The spring and fall seasons have wide and abrupt variations of temperature and precipitation, resulting in occasional hazards to the growth of crops. Killing frosts in late spring or early fall occasionally damage crops. Abnormally heavy rainfall during the spring sometimes retards the planting of crops so long that they do not mature properly before the fall frosts. Now and then the fall seasons are too wet for satisfactory maturing of crops, and lower yields and poorer quality of grain result. These unfavorable weather conditions are not common. Generally, seasonable planting can be made in the spring. The well-distributed rainfall of the summer favors a satisfactory growth of corn and other fall-maturing crops and at the same time does not prevent harvesting of small grains, which have a shorter growing season.

The average frost-free season covers a period of 147 days, from May 7 to October 1. Killing frosts have occurred as late as May 30 and as early as August 30. In 3 out of 20 years, killing frosts occurred in the spring 10 days or more later than the average date (May 7), and the frost-free season was 15 or more days shorter than the average. In 4 out of 20 years, fall killing frosts occurred 10 days or more earlier than the average date (October 1).

The mean annual rainfall is 30.83 inches, two-thirds of which falls during the frost-free season. In 1 out of 5 years the annual rainfall is less than 25 inches. The rainfall during the warm season from April to September, inclusive, averages 22.95 inches, but in 3 out of 20 years it is less than 75 percent of the average.

Over the 20-year period 1895–1914, there were nine times including 30 consecutive days sometime between March and October 1 when the rainfall was less than one-fourth inch a day. On the average, this 7-month season has had 80 days with from 0.01 to 0.25 inch of rain, 30 days with from 0.25 to 1 inch of rain, and 1 day with more than 1 inch of rain. The average frost-free season has 3 days on which some hail falls.

During the period October 1 to May 1, the average snowfall is 27.7 inches. The covering of snow is an advantage to the tame-hay and fall-seeded crops, which suffer damage from winter-killing in unusually cold and snowless winters. The climatic hazards to crops on the individual soils are described in the following pages.

Table 1, compiled from records of the United States Weather Bureau station at Mason City, gives the normal monthly, seasonal, and annual temperature and precipitation, which are representative of the general climatic conditions over Cerro Gordo County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Mason City, Cerro Gordo County, Iowa*

[Elevation, 1,148 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1906)	Snow, average depth
	°F.	°F.	°F.	Inches	Inches	Inches	Inches
December	20.2	56	−26	0.98	0.22	1.40	5.7
January	13.5	54	−34	.86	1.35	1.15	6.2
February	16.9	65	−35	.98	.23	1.55	6.4
Winter	16.9	65	−35	2.82	1.80	4.10	18.3
March	30.4	83	−18	1.40	.26	3.80	4.2
April	45.9	91	11	2.30	.31	1.90	1.3
May	57.5	94	24	4.38	2.32	7.00	0
Spring	44.6	94	−18	8.08	2.89	12.70	5.5
June	66.1	99	33	4.71	1.20	2.75	0
July	71.6	104	38	3.50	.71	6.73	0
August	68.9	102	30	4.16	4.84	5.54	0
Summer	68.9	104	30	12.37	6.75	15.02	0
September	60.9	100	15	3.90	2.61	5.76	0
October	48.4	88	9	2.06	.97	1.75	.5
November	32.9	75	−14	1.60	.25	2.80	3.4
Fall	47.4	100	−14	7.56	3.83	10.31	3.9
Year	44.5	104	−35	30.83	15.27	42.13	27.7

AGRICULTURAL HISTORY AND STATISTICS

The first settlement in Cerro Gordo County, with a view to claiming land, was made in 1851 by two hunters from Clayton County. The following year land was claimed by other settlers at the present sites of Mason City and Rock Falls. Dubuque, the nearest supply depot, was 150 miles to the southeast. The early settlements, therefore, were located near streams where timber was available for building, animals could be trapped and hunted for meat, fur, and hides, and the nearby prairie land could be planted to food crops or used for grazing.

The State census of 1856 gave the county a population of 632, composed of 146 families and 143 militia. In that year 126 individuals had land holdings totaling 18,228 acres, or an average of about 145 acres for each owner. The pioneer subsistence type of farming at that time is shown by the small listings given by this census for acreages of corn, wheat, oats, meadow hay, and potatoes, numbers of cattle and hogs, butter and cheese made, and wool clipped. During the period 1865 to 1875, the present railroads were constructed and put into operation. With this means of transportation it was possible to grow crops and raise livestock in excess of the local demand, and a rapid increase in production followed. The measure of this expansion is shown in table 2, compiled from the State censuses for 1867 and 1875.

TABLE 2.—*Comparative farm data for the years of 1867 and 1875 for Cerro Gordo County, Iowa* [1]

Year	Population	Dwellings	Wheat	Corn	Oats	Barley	Rye	Flax	Potatoes
		Number	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
1867	1,988	326	2,139	2,635	1,974	74			142
1875	6,688	1,335	28,199	9,512	7,199	1,027	30	190	431

[1] Taken from the Census of Iowa, as returned in the year 1867 (*5*) and the Census of Iowa, as returned in the year 1875 (*4*).

By 1880, according to the Federal census, the county had 1,387 farms with an average size of 155 acres, covering 59.3 percent of the total land area. All farm property averaged $3,539 a farm in value. The rural population was 8,951. The acreage of wheat was double that of corn, four times that of oats, and five times that of hay. Barley, rye, potatoes, buckwheat, and flax were minor crops. Although wheat was still the main cash crop, the farmers were increasing their numbers of livestock and their acreage of feed crops. The agriculture early became a well-balanced general type combining the raising of livestock and the production of grain. The comparative importance of the various crops and the relative importance of crops and livestock has shifted and continues to shift. By 1900 all the available land was claimed, the number of farms increased to 1,957, their average size increased to 180.5 acres, the percentage of land in farms increased to 97.5 percent, the rural population increased to 13,926, and the property value of the average farm increased to $9,610. The production of corn, oats, and hay expanded enormously; whereas the acreage of wheat was cut to less than one-tenth of the acreage in 1879. The raising of cattle and hogs, together with the growing of corn, oats, hay, and forage crops, as feed and market crops, were the most important types of farming in 1900.

After 1900, when all the available land had been taken up by farmers, a steady improvement of the farms began. Although much of the improvement has consisted of the construction of farm buildings and fences, the land itself has been improved by better tillage and cropping methods and by artificial drainage. Improved tillage implements have made it possible to prepare better seedbeds and to keep intertilled crops and the following crops freer from weeds. The farm-building construction has provided better accommodations for the care of livestock and the storage of grains. There are about 500 silos in the county. Many of the farm homes provide the family with all the modern conveniences of a home in a town with public utilities.

Land and farm areas have not changed greatly since 1900. In 1935 there were 2,048 farms, with an average size of 170.1 acres, covering 96 percent of the total land area. The value of land and buildings was $11,656 a farm, or $68.51 an acre. The farm population was 9,738. Corn and oats continue to be the major crops. Hay is the third most important crop, although hay from a smaller acreage is cut than before 1909. Timothy and clover are declining as sources of hay, and alfalfa and other legumes are increasing. A very recent development is the expansion in the production of soybeans.

The trend in production of crops may be traced from the acreages of the principal crops given in table 3.

TABLE 3.—*Acreage of principal crops in Cerro Gordo County, Iowa, in stated years*

Crop	1879	1889	1899	1909	1919	1929	1934
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn						112,237	103,420
For grain	33,090	63,784	99,235	89,044	80,360	85,159	70,607
For forage, silage, and hogging down					[1] 10,929	27,078	32,813
Wheat, threshed	65,642	2,477	5,846	590	1,901	391	403
Oats:							
Threshed	15,511	55,902	90,745	73,572	75,667	71,400	78,100
Cut and fed unthreshed						191	2,283
Barley	2,718	1,653	9,171	3,226	2,011	10,452	3,033
Rye	41	130	981	118	65	343	387
Flax		4,136	6,399	202	107	319	135
Mixed grains						8,962	1,002
Sugar beets				172	474	217	933
Potatoes		1,413	1,720	1,942	1,485	1,166	1,420
Soybeans						892	13,070
All hay	17,430	68,069	42,730	53,721	42,551	33,171	[2] 34,959
Timothy and clover				39,772	30,657	20,269	4,693
Clover alone			1,192	651	983	4,360	917
Alfalfa				13	84	2,804	6,230
Legumes for hay					9	882	12,609
Other tame hay			25,915	2,236	1,561	1,076	10,510
Wild hay			15,623	11,049	9,257	3,920	(3)

[1] For forage only.
[2] Includes sorghums for silage, hay, and fodder.
[3] Included with other tame hay.

In addition to the crops listed in table 3, the census of 1930 reports the production of clover seed on 800 acres, timothy seed on 335 acres, and alfalfa seed on 96 acres in 1929. These crops were not reported by the 1935 census. Vegetables, chiefly dry onions, sweet corn, cabbage, tomatoes, and watermelons, were grown on 352 acres in 1929 and on 448 acres in 1934.

At the time of settlement, more than one-third of the land in the county was not well enough drained to produce satisfactory crops. Prior to 1890, only the better-drained areas were cropped, and the poorly drained tracts were grazed, cut over for hay, or left unused. About 1900 interest in artificial drainage became widespread, and the individual farmer did what he could to drain his land. The problem of proper outlets, however, made cooperative action necessary, and county drainage districts were organized. The drainage districts in the western tier of townships have had to go considerable distances for outlets. The 1930 Federal census reports that 115,331 acres are covered by drainage enterprises. Before drainage was provided, about one-fourth of the land in the drainage districts could produce normal crops; about one-fourth, no crops at all; and the remaining half, small crops. Now, after drainage, almost three-fourths of the land in these districts is reported to be normally productive, slightly more than one-fourth partly productive, and only 382 acres still is entirely unfit for cropping. Unorganized independent drainage improvements benefit an additional area of about 6,000 acres. Up to the date of the 1930 Federal census, 35.8 miles of ditches and 539.7 miles of tile drains had been completed, reaching 950 farms. More than three-fourths of this construction was done during the period 1905 to 1920. Drain tile is obtained from tile works at Mason City. Practically all of the smaller depressions and many of the larger ones are wet for periods of only a few days at a time, as compared with the marshy conditions that existed before drainage. The water table in the wetter sections has been measurably lowered. Shallow wells have become dry intermittently, and for a dependable supply of water wells are drilled to depths of 60 or more feet.

The present type of farming in this county combines the production of grain and livestock. Most of the crops are fed to livestock, and the greater part of the farm income is derived from the sale of livestock and livestock products. Dairy products furnish a considerable part of the farm income. In periods of economic stress, the tendency is to shift from beef raising to hog raising and to dairying and poultry production, because these latter enterprises give a more rapid turn-over in a shorter production period. The different types of farming, as given in the 1930 Federal census, are shown in table 4.

TABLE 4.—*Types of farming*[1] *in Cerro Gordo County, Iowa, as given by the 1930 Federal census*

Type of farm	Farms	Average size of farms	Percent of total farm land in county	Type of farm	Farms	Average size of farms	Percent of total farm land in county
	Number	*Acres*	*Percent*		*Number*	*Acres*	*Percent*
Animal specialty	915	196	51.8	Truck	12	58	0.2
General	400	165	19.0	Crop specialty	2		
Dairy	287	154	12.8	Abnormal and unclassified	141	63	4.1
Cash grain	204	199	11.8				
Poultry	29	23	.2				
Self-sufficing	14	25	.1	All farms	2,004	172	100.0

[1] On the basis of 40 percent or more of the total value of products coming from the source given.

The poultry, truck, and crop-specialty farms are the most highly specialized, but on practically all of the other farms, crop and livestock production are about equal. A more detailed analysis of the sources of income of these types of farms indicates that farming is diversified, with no marked trend toward specialization except on a few farms. Hog raising is the most important livestock enterprise, and dairying returns slightly greater revenues than beef production. Feed crops are produced in excess of the requirements for feed, and it is the sale of these surpluses that brings the greatest part of the direct cash income from crops. One of principal crops grown for market is potatoes, and a few individual growers and groups of growers produce and market potatoes in carload lots. Sugar beets are a minor market crop, for which the income is not separately listed. This crop is grown under contract with the sugar factory at Mason City. Sweet corn and tomatoes for canning, onions, and cabbage are other crops grown for sale outside the county. The other truck crops, with the exception of cantaloups and cucumbers, are produced on only a small scale for county markets.

The orchard and small-fruit crops are marketed locally, with small surpluses going to nearby markets. Strawberries and raspberries are the principal small fruits grown, and apples, plums, and cherries are the chief orchard crops.

Nearly all of the farms are stocked with hogs, horses, cattle, and poultry, but on only one-fifth of the farms are sheep raised. On most farms cattle are kept for both milk and meat production, so that a classification of the herds as dairy cattle or beef cattle cannot be clearly made from the census reports. The figures taken from the 1930 Federal census show that almost one-half of the cattle are cows and heifers, of which about one-seventh are kept for beef production. Truck routes of local creameries reach all parts of the county, and most farmers market milk and cream in this way, but a few farmers located near towns operate routes for direct sale of milk to customers.

In 1929, 16,519 cows were milked and 8,514,304 gallons of milk were produced. The value of dairy products sold was $1,252,607. Most of the dairy products are marketed in the form of butterfat, of which 1,875,250 pounds, valued at $900,120, were sold in 1929. Next in importance is whole milk, of which 1,776,901 gallons, valued at $337,611, were sold in 1929. In 1934, 18,198 cows were milked and 8,736,185 gallons of milk were produced.

About two-thirds of the sheep are clipped, and the wool is sold to local buyers or through a local wool pool. In 1929, 35,862 pounds of wool, valued at $11,117, were shorn from 4,382 sheep. In 1934, 56,613 pounds of wool were shorn from 6,537 sheep.

Poultry raising on most farms is a side line contributing a part of the income received for livestock products. All the fowls and eggs are marketed through local produce houses. The value of the 451,468 chickens raised in 1929 was $370,204; 233,851 of these, valued at $201,112, were sold alive or dressed. The value of the 1,511,181 dozens of eggs produced in 1929 was $408,019; 1,139,251 dozens of these, valued at $307,598, were sold. In 1934, 433,096 chickens were raised, and 1,245,363 dozens of eggs were produced.

Most of the livestock fattened for market are raised on the farm where produced. Some farmers buy additional cattle for feeding at local sales, and a few carloads are shipped in from the Omaha and Sioux City markets. Feeder lambs occasionally are obtained in the same way. Some farmers obtain baby chicks from hatcheries for feeding and marketing.

The quality of the livestock is high. Most of the farmers use purebred sires. Some have purebred animals making up part of their herd, with the rest good grade animals. Only a few farmers maintain entire herds of purebreds.

The number and value of livestock in stated years are given in table 5.

TABLE 5.—*Number and value of livestock in Cerro Gordo County, Iowa, in stated years*

Livestock	1880, number	1890, number	1900, number	1910		1920		1930		1935,[1] number
				Number	Value	Number	Value	Number	Value	
Horses	5,745	9,433	12,696	12,802	$1,510,404	13,801	$1,130,884	11,129	$935,187	9,375
Mules	148	132	130	126	14,730	230	27,340	380	31,804	301
Cattle	15,078	46,955	53,179	45,827	1,144,314	51,200	2,882,046	45,156	2,506,176	52,694
Sheep	3,014	5,116	18,170	5,793	31,736	4,440	64,129	8,118	69,980	24,645
Swine	29,106	55,518	77,924	53,187	584,871	64,216	1,472,771	90,563	1,232,834	58,217
Poultry	45,166	142,224	182,223	194,596	109,762	251,654	257,735	[2] 274,525	[2] 227,856	[2] 266,816

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

The most popular breeds of hogs are Duroc-Jersey, Poland China, Chester White, and Hampshire, but some farmers prefer the Berkshire breed, the first introduced into this county. Cattle on the dairy farms are of the Holstein-Friesian, Guernsey, and Jersey breeds. The Holstein-Friesians are more popular with the dairy farmers. Farmers not specializing in dairying keep more Holsteins than Guernseys, and there are very few Jerseys. The Shorthorn is the most common among the cattle kept for beef production, particularly on those farms not specializing in raising beef cattle. Many farmers raising cattle mainly for beef keep Aberdeen Angus instead of Shorthorn, and a few have Herefords. The sheep raisers choose between the Shropshire, Hampshire, and Southdown breeds. The horses kept as work animals are mainly of mixed blood. Among the better horses the Percheron breed predominates, followed by the Belgian. A few farmers prefer the Clydesdale and Shire breeds. About 3 percent of the farmers use mules.

Fat cattle and hogs are consigned to the Mason City, St. Paul, and Chicago markets. Much of the livestock going to the nearby markets is trucked instead of shipped by rail. Lambs and fat sheep are consigned to St. Paul and Chicago. Five cooperative livestock-shipping associations operate in the county, although much of the marketing is done by individual farmers or groups of farmers.

Grain and seed crops are handled by local elevators and dealers at the various shipping points. Eleven cooperative elevators operate in the county. Other cooperative marketing agencies are a milk-producers' association and a wool-growers' association.

More than one-half of the farms are operated by tenants, the 1935 Federal census reporting the proportion of tenancy as 59.4 percent. A crop and/or livestock share type of lease is somewhat more common at present (1936) than a cash lease. The tenant's share ranges from two-fifths to three-fifths of the profits, depending on the amount of livestock and equipment furnished by him. Cash rental ranges from $4 to $10 an acre. On farms where the owner shares only in the crop, it is customary to set a cash rental, ranging from $3 to $5 an acre, on the pasture and grassland.

Under tenant operation a greater acreage of the farm is cropped, a more continuous system of cropping to corn and small grains is practiced, the farm equipment is poorer, as a rule, and usually less livestock is kept than under owner operation. Certain practices that tend to lower the fertility of the soil are prevalent in the present system of farm operation by tenants.

Most of the farm labor is performed by the farmer and his family, additional help being hired only during small-grain harvest, haying, and corn picking. Many farmers exchange labor for threshing, corn shelling, silo filling, and other work that is more efficiently done by crews. According to the 1930 Federal census, 1,196 farms, or 59.7 percent of the farms in the county, reported an expenditure of $434,674 for labor in 1929, or an average of $363.44 a farm reporting. Most of the labor is supplied locally, except the Mexican laborers, who are brought in for work in the sugar-beet fields.

In 1929, 1,357 farms, or 67.7 percent, reported the purchase of feed to the amount of $451,377, or an average of $332.65 a farm reporting.

Very little commercial fertilizer is used. Only 274 farms, or 13.7

percent, reported the purchase of fertilizer in 1929, to the amount of $23,868, or an average of $87.11 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[3] and its content of lime and salts are determined by simple tests.[4] 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 recognized. Thus, Carrington, Clarion, and Webster 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, sandy loam, silt 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 silt loam are soil types within the Clarion series. Except for the texture of the surface soil, these soil types 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.

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[3] 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.

[4] The total content of readily soluble salts is determined by the use of the electrolytic bridge. The presence of lime ($CaCO_3$) is detected by effervescence on the application of dilute acid.

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 frequently are 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 a 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

Cerro Gordo County is in the Prairie soils region of the United States, where ample rainfall and moderate temperatures promoted a rich and luxuriant growth of prairie grasses. The growth and decay of the grasses through centuries have resulted in the accumulation of the large amount of organic matter in the surface layers of nearly all of the soils of this county and have imparted to them a black or nearly black color. The thickness of the black surface layer and the intensity of its color in any one place are influenced directly by the relief, the drainage, and the character of the underlying materials. Only one soil type, Lindley loam, which originally supported a forest growth, is light-colored and poor in organic matter.

Extensive areas of dark-colored soils, covering almost one-half of the total area of the county, have developed under conditions of good surface and subsoil drainage. The principal representatives of these soils are the Carrington soils of the rolling uplands in the eastern part, underlain by glacial till of the Iowan stage, and the Clarion soils of the more rolling uplands in the western part, underlain by the younger glacial till of the Wisconsin stage. Leaching has proceeded to a depth of 5 to 6 feet in the older Iowan drift, but highly calcareous material lies only 18 to 30 inches below the surface of soils developed over the Wisconsin drift.

A large proportion of the soils on the upland and all the soils of the bottom land have developed under conditions of poor drainage. This has resulted in the formation of very dark brown or black surface soils, ranging from 15 to 20 inches in thickness, underlain by drab-gray or mottled gray and brown heavy-textured subsoils. The combined area of such soils almost equals that of the soils developed under conditions of good drainage. The most extensive of these immature soils are the Webster, Floyd, Clyde, and Benoit soils. The Webster soils generally occupy flat areas, most of which are now artificially drained, within bodies of the Clarion soils in the western part of the county, and are underlain by Wisconsin drift. The Floyd soils are associated in a similar manner with the Carrington soils in the eastern part and are underlain by Iowan drift. The Clyde soils are widely distributed in stream valleys and depressions under conditions of excessive moisture. The Benoit soils are formed on stream terraces, mainly in the southern and eastern parts of the county.

Certain inextensive soils, chiefly members of the O'Neill series, have a low water-holding capacity, owing to the porous character of their lower subsoil layers.

Corn and oats are the principal crops grown and their combined acreage equals more than one-half of the total area of the county. This acreage is rather uniformly distributed, and on practically all of the farms the care of these two crops constitutes the greater part of a season's work. The next crop of wide distribution, although not so extensive in acreage, is hay. Nearly every farm produces some hay, either from permanent meadows or from fields sown to timothy and legumes.

The distribution of crops is influenced in some measure by the kind of soil. The dark-colored well-drained soils of the smooth areas are suited to the production of corn and are used repeatedly for this purpose. Other soils are used for growing corn but are not especially suited to this crop. The excessively drained soils cannot furnish a sufficient supply of water for the corn crop, and therefore they produce low average yields compared with the better soils. Excessive moisture in the low or undulating areas also decreases yields of corn. Differences in the lime content of the various soils do not greatly affect yields of corn and oats but do affect markedly the growth and yields of alfalfa and other legumes, which return higher yields on the calcareous soils of the western part of the county.

The most important factor determining the distribution of crops in this county is the supply of moisture in the soils. Injury to growing crops in dry seasons is greatest on soils with porous sandy or gravelly substrata. Excessive moisture generally is associated with depressed topography, and in this section of sags and swales, low ridges and wide depressions, a close relationship exists between the soils and local surface configuration. The crop, therefore, is affected both by moisture conditions and by the composition of the soil. Nearly every farm has areas of both well-drained and poorly drained land, so that on few farms is it necessary to plant cultivated crops on land that is unfavorable to them. Corn and other cultivated crops are, therefore, grown on the well-drained soils of the higher land, and poorly drained soils are kept in useful and necessary pasture and hay land.

The more important soils may be placed in three broad groups on the basis of their natural drainage, as follows: Well-drained soils, imperfectly and poorly drained soils, and excessively drained soils. Two additional groups include organic soils and miscellaneous land types.

In the following pages the soils are described in detail and their agricultural relationships are discussed; their distribution and location are shown on the accompanying soil map; and their acreage and proportionate extent are given in table 6.

TABLE 6.—*Acreage and proportionate extent of the soils mapped in Cerro Gordo County, Iowa*

Soil type	Acres	Percent	Soil type	Acres	Percent
Carrington silt loam	52,480	14.5	Fargo silt loam	1,280	0.4
Carrington loam	6,592	1.8	Bremer silt loam	1,472	.4
Clarion loam	37,760	10.4	Millsdale silty clay loam	4,608	1.3
Clarion loam, rolling phase	25,216	6.9	Millsdale loam	832	.2
Clarion silt loam	13,888	3.8	Lamoure silty clay loam	6,592	1.8
Clarion fine sandy loam	640	.2	Lamoure silt loam	1,664	.5
Dodgeville silt loam	17,216	4.7	Wabash silt loam	2,752	.8
Dodgeville loam	3,712	1.0	Wabash loam	2,304	.6
Tama silt loam	4,032	1.1	Cass loam	384	.1
Lindley loam	2,496	.7	O'Neill loam	23,424	6.5
Waukesha silt loam	3,136	.9	O'Neill silt loam	3,712	1.0
Webster silty clay loam	40,128	11.1	Dickinson loam	2,304	.6
Webster silt loam	22,272	6.1	Dickinson sandy loam	1,728	.5
Webster loam	1,216	.3	Dickinson loamy fine sand	1,152	.3
Floyd silt loam	17,664	4.9	Pierce loam	576	.2
Floyd silty clay loam	2,304	.6	Peat	8,576	2.4
Clyde silty clay loam	17,344	4.8	Muck	4,544	1.3
Clyde silt loam	3,776	1.0	Beach sand	128	(1)
Benoit silt loam	15,104	4.2	Quarries	512	.1
Benoit silty clay loam	4,032	1.1			
Benoit loam	896	.2	Total	362,880	
Fargo silty clay loam	2,432	.7			

[1] Less than 0.1 percent.

WELL-DRAINED SOILS

The group of well-drained soils includes soils that have good natural drainage but are retentive of sufficient moisture for the use of crops in normal seasons. The water-holding capacity depends primarily on the texture of the various layers of the soils. The lower layers are not heavy and impervious enough to retard the percolation of excessive moisture nor so loose and porous as to allow the rapid escape, immediately after rains, of soil water that later may be needed by the crops.

At the time of settlement of this county, these soils could be cultivated immediately, without drainage, and as a result they have been under cultivation longer than the more poorly drained soils. At present they are still valuable farming soils but are naturally less productive than some of the soils that were originally poorly drained.

Soils having good natural drainage cover 46 percent of the land surface of the county. They include 10 soil types and 1 phase and belong to 6 soil series.

Extensive areas of dark-colored soils also have developed under conditions of good surface and subsoil drainage. The principal members of this group are the Carrington soils in the eastern part of the county and the Clarion soils in the western part. Two types of the Carrington series—a loam and a silt loam—are recognized. These soils are characterized by dark-colored surface layers, underlain by lighter brown or yellowish-brown subsoils. At greater depths the soil grades into the glacial till from which it is derived. As the till is of the older Iowan stage, the soil and underlying material are leached free of carbonates to a depth of 5 or 6 feet. These soils occupy gently rolling uplands.

The Clarion soils resemble the Carrington soils but are underlain by the younger glacial till of the Wisconsin stage. Leaching of carbonates has not proceeded so long as in the Iowan drift, and the highly calcareous material lies at a depth ranging from 18 to 30 inches. The Clarion soils occupy more rolling upland than do the Carrington soils. A few boulders are scattered over the surface of all soils of these two series and are distributed through the soil material. As a rule, the stony material is more abundant in the Clarion soils.

The Dodgeville soils are shallow fairly well drained soils with mellow surface layers over plastic sandy clay, which rests on limestone at a depth generally ranging from 24 to 36 inches.

Tama silt loam, an important soil in other parts of Iowa, does not cover a large area in this county. It has a well-oxidized and leached subsoil like that of the Carrington soils but is developed over loess. The material is a mellow silt loam throughout the profile and contains no gravel or boulders.

Lindley loam is a light-colored soil developed from the Iowan glacial till under a forest vegetation.

The Waukesha soils on the terraces have a profile similar in appearance and stage of development to that of the Carrington soils of the upland but are developed from alluvial deposits under conditions of good drainage and contain no gravel or boulders. The subsoil is moderately heavy textured.

Carrington silt loam.—The surface soil of Carrington silt loam, to an average depth of about 13 inches, is very dark grayish-brown silt loam, which, when wet, appears almost black. A part of the material composing this layer is finely granular, and the remainder consists of loose silt. Below the surface soil, and continuing to a depth of about 26 inches, is a transitional layer in which the color changes from dark grayish brown to brown and the texture from silt loam to silty clay loam, with a small proportion of glacial sand and gravel in the lower part. The next lower 6-inch layer consists of yellowish-brown silty clay loam containing more sand and gravel than the layer above. Faint gray and rust-brown stains are present in this layer. Between depths of 32 and 57 inches, the material is yellowish-brown silty clay, somewhat more compact than the material in the layers above but well aerated and not impervious. Gray and rust-brown stains are more prominent with increasing depth. The soil from the surface downward through this layer contains no calcium carbonate (lime) and is acid to neutral in reaction. Below a depth of 57 inches the soil is underlain by the slightly altered glacial till, from which this soil is developed, consisting of yellowish-brown silty clay loam containing many glacial gravels and boulders. Below a depth of 5 feet a small part of the stony material is composed of limestone, and spots and concretions of calcium carbonate also are present.

Within the areas mapped as Carrington silt loam there are a number of minor variations, which affect the agricultural value of the land. A surface soil darker and deeper than typical occurs on nearly flat areas of the upland. These areas are very productive, but on account of the slow surface drainage require underdrainage by tile. The largest two areas of this kind are in the southeastern corner of Lime Creek Township and the northeastern corner of Falls Township. Areas with a heavy subsoil are widely distributed over the upland plain between Shell Rock River and Lime Creek in Portland Township. In these areas the subsoil at a depth of 30 inches is yellowish-brown plastic silty clay with rust-brown and gray stains. It is sufficiently impervious to retard the downward percolation of water through the soil after rains, and the fields are more difficult to keep in good tilth, particularly in wet seasons. Carrington silt loam areas with a sandy substratum occur in sections 16 and 17 of Dougherty Township, on the upland within the drainage basin of Coldwater Creek. The soil in these areas resembles the Dickinson soils in some respects, but the sandy layer is 3 feet or more below the surface and is overlain by loam and silt loam layers that are very retentive of moisture.

Carrington silt loam is extensively developed on the Iowan till plain in the eastern half of the county and covers 82 square miles, or 14.5 percent of the total area. There are very few sections without areas of this soil. More than one-half of its acreage is in Dougherty, Owen, Bath, and Falls Townships, but all townships except the four in the westernmost tier contain areas of this soil.

The surface of Carrington silt loam ranges from undulating to rolling, but the greater part is gently rolling, with long even slopes and rounded hill crests. Natural drainage is nearly everywhere satisfactory, but, on the undulating and more nearly level areas, installation of tile drains is beneficial.

Nearly all of Carrington silt loam is under cultivation and is well suited for the production of the staple crops. Trees grow well on narrow bluffs descending to the larger stream valleys and in shelterbelts, which have been planted on nearly every farm. Some areas that are not in cultivation are included in permanent pasture, in association with poorly drained soils.

The chief crops, named in the order of their acreage, are corn, oats, timothy and clover, soybeans, alfalfa, barley, and potatoes. Corn yields from 25 to 75 bushels an acre, averaging about 45 bushels, and when cut for fodder or silage, yields from 6 to 10 tons; oats yield from 30 to 55 bushels; timothy and clover supply most of the hay, yielding from 1 to 2½ tons; soybeans are an emergency hay crop yielding from 2 to 3 tons, or, when harvested for seed, from 15 to 20 bushels; alfalfa yields from 2 to 4 tons and generally makes higher yields than any other hay crop; barley yields from 25 to 40 bushels; potatoes from 90 to 150 bushels; sweetclover usually is pastured, but when cut for hay it yields about 1½ tons; wheat yields from 15 to 30 bushels; and rye from 10 to 25 bushels.

Although crop yields on Carrington silt loam are, in the main, satisfactory, experiments have proved that certain soil-improvement practices are beneficial in increasing yields. Wherever drainage is inadequate, installation of tile is necessary, in order to secure good underdrainage. The soil is acid, and liming results in larger yields of legumes and the succeeding green crops. Applications of farm manure increase crop yields. It is the most economical and generally used soil amendment, but the supply produced is not sufficient to treat all the cropland properly. Phosphate fertilizers have given good returns in experimental trials and are the most commonly used commercial fertilizers. Both ground rock phosphate and superphosphate are applied, and both are recommended for trial if the farmer

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has any doubt as to which form should be used. The more expensive commercial mixed fertilizers produce yields but little larger than those given by the phosphate fertilizers, and in most experiments the added expenditure has not proved profitable. Phosphate fertilizers usually give substantial increases in yields of potatoes and truck crops. Rotation of crops including a legume is generally considered a good practice. The addition of organic matter and nitrogen by plowing under the residues of leguminous crops is particularly beneficial on this soil.

Carrington loam.—The surface layer of Carrington loam is very dark grayish-brown mellow loam about 10 inches thick. The underlying layer, to a depth of 24 inches, is transitional, changing from moderately dark brown to brown and from loam to heavy loam or silt loam, and passing, below a depth of 18 inches, into yellowish-brown silty clay loam. Below this, to a depth of 38 inches, is yellowish-brown plastic silty clay loam containing glacial sand and gravel and faint rust-brown and gray stains. Between depths of 38 and 62 inches the material is plastic clay containing glacial sand and boulders and is faintly colored by rust-brown iron stains and gray splotches. Below a depth of 62 inches the soil grades into Iowan till containing small spots of calcium carbonate. A few boulders are scattered over the surface and through the subsoil. The subsoil varies in its content of sand and gravel from place to place, but the average texture is heavy. This soil is almost identical with Carrington silt loam except for the loam texture of the surface layer.

All the variations described in the Carrington silt loam areas are present in Carrington loam but in much smaller areas. The areas with a deep black surface soil occur only in small strips on foot slopes, none of which require tile underdrainage. The small areas having a compact subsoil occur only in Lincoln and Portland Townships; the areas with a sandy substratum, which is the most common variation, cover approximately one-tenth of the total acreage of the soil type, especially in Lime Creek and Dougherty Townships. Crops on the last-mentioned areas show the effects of drought sooner than those on the heavier silt loam.

The surface of Carrington loam is rolling. This soil generally occupies narrow rounded crests and shorter less even slopes than does Carrington silt loam. Natural drainage is everywhere good. In a few places on the more abrupt slopes the surface soil may have been thinned by erosion. In most places Carrington loam did not support quite so thick a growth of prairie grasses during the period of its formation as did the silt loam, and as a result its content of organic matter is somewhat lower.

About 80 percent of Carrington loam is in harvested crops, about 3 percent in forest or woodland pasture, and the rest in pasture. This soil is not considered so productive as Carrington silt loam; but drought ordinarily does not affect crops on it, and yields are much more satisfactory than on the Dickinson soils. Yields of the general farm crops average a little lower than on Carrington silt loam. Carrington loam is handled in about the same way as the silt loam and calls for the same management as is recommended for that soil, in order to maintain and improve its productivity.

Clarion loam.—In undisturbed grassland the 2-inch surface layer of Clarion loam consists of dark grayish-brown silt loam. Under virgin conditions this layer was held together by numerous grass roots. The next layer, to an average depth of about 10 inches, is very dark grayish-brown loam, which appears black when wet. The structure of this layer is finely granular, but the granules are soft and indistinct. The third layer, which continues to a depth of about 25 inches, is transitional in color, grading from very dark grayish brown in the upper part to brown in the lower part. The structure of this material is distinctly granular, and the granules are larger than in the layer above, being about one-fourth inch in diameter. The texture of this layer is slightly heavier than that of the layer above. The soil is leached of calcium carbonate and to this depth has a neutral or slightly acid reaction. The next lower layer is grayish-yellow silty clay loam with a distinct gray cast and contains finely divided calcium carbonate. Below a depth of 32 inches the material is light yellowish-brown silty clay loam containing lime concretions and rust-brown iron stains. The abundance of lime gives a somewhat white appearance to the dry subsoil exposed in road cuts. Glacial boulders are scattered over the surface and through the soil, but they are not numerous and, being small, are easily removed from the land. In one area, in section 34 of Lincoln Township, boulders are so abundant on the surface and in the soil as to interfere seriously with cultivation.

Included with this soil in mapping are local variations, occurring on smoother areas or at the bases of slopes in the more rolling areas, in which the surface soil is darker and deeper than typical. The subsoil in these areas is in many places stained with iron or slightly mottled below a depth of 30 inches. In other places the surface soil is thinner and lighter in color than is typical. Such spots occur on the crests of hills or ridges and on the steeper slopes. Small gravel pockets—too small to map separately—occur in several places.

Clarion loam is the most extensive soil of the drift plain of the Wisconsin glaciation, which covers the western half of the county, and it is the third largest soil in the county. In many sections this soil forms an intricate pattern with members of the Webster series. The largest unbroken stretch of Clarion loam occurs in Grimes Township on smooth or gently rolling relief.

About 90 percent of the area of Clarion loam is in cultivated crops, and the rest is in pasture and wild-hay land. Most farms including areas of Clarion loam also include areas of poorly drained soils, which furnish pasture and thereby release a large proportion of Clarion loam for cultivated crops. The soil is very productive of the staple grain and hay crops. Corn yields range from 25 to 75 bushels an acre, with an average of 45 bushels. Maximum yields of corn may not be so high as on the Webster soils, but average yields over a period of years are nearly the same. Clarion loam has excellent physical properties which allow early planting, and corn matures without any deterioration in quality, even in wet years. Oat yields range from 40 to 50 bushels an acre. Oats have less tendency to produce a large amount of straw at the expense of grain than on the Webster soils, and the grain matures earlier. In favorable years the Webster soils may produce higher maximum yields, but the average yield on Clarion loam is higher. Clover-and-timothy hay yields from 1¾ to 2 tons an acre and alfalfa from 2 to 3 tons. Stands of alfalfa can be obtained more easily on Clarion loam than on the less calcareous Carrington soils. Sugar beets do not do so well as on the Webster soils and are grown on only a small acreage.

Crops on Clarion loam show a good response to manure, and liberal applications are recommended. Good stands of legumes may often be obtained without liming, but the surface soil is slightly acid, and liming will sometimes increase yields of these crops. On the basis of experiments, phosphate fertilizer is recommended. The improvement in the physical properties gained by plowing under manure and crop residues is not so marked as in the heavier Webster soils but is a beneficial practice for maintaining productivity. Many of the slopes should be kept seeded longer in the crop rotation, in order to minimize erosion.

Clarion loam, rolling phase.—The rolling phase of Clarion loam covers a total area about two-thirds as large as that of typical Clarion loam. It occurs in close association with the typical soil, and in many places the separation is based on only slight differences of slope.

The surface soil of Clarion loam, rolling phase, is dark grayish-brown finely granular loam. The thickness of the dark-colored layer in few places exceeds 10 inches, and over the greater part of the areas of this soil it ranges from 5 to 8 inches. Below the surface soil is brown or yellowish-brown friable silty clay, which changes to buff-colored silty clay at a depth of about 18 inches. Lime is present at different depths, and where run-off is rapid or erosion has been severe the lime-bearing material is near the surface. In most places, however, lime occurs at a depth ranging from 15 to 30 inches. Below a depth of 30 inches the soil is underlain by the glacial till consisting of light yellowish-brown or buff silty clay, which contains a large amount of lime. Boulders and gravel are scattered over the surface and throughout the soil in greater abundance, compared with the typical soil.

Comparatively rapid run-off takes place on the steeper slopes, less moisture penetrates the soil, and erosion, both natural and accelerated, is rather rapid, and as a result the dark-colored surface soil is thin. Small areas, included with this phase on the soil map, do not have the characteristics of the typical soil. In places the dark-colored layer is entirely lacking and the yellow or brown glacial till is exposed. The dark-colored surface soil accumulates in narrow bands at the foot of slopes and in places is more than 20 inches thick. Most of the areas having a large quantity of boulders on the surface occur in the morainic upland northwest of Lime Creek in Grant Township. In a few small bodies, large quantities of gravel are near the surface, but these areas are too small to indicate on the soil map.

The slope of this land allows the rapid run-off of rain water, resulting in damage to crops during seasons of drought. The droughty condition is especially noticeable on the sandier spots where the soil has lower water-holding capacity than elsewhere.

About 80 percent of this land is used for the production of cultivated crops, 16 percent is in pasture, and 4 percent in hardwood forest, hazel brush, or woodland pasture. General farm crops are grown on the cultivated areas, but the yields are lower than on typi cal Clarion loam. In good years, corn yields from 30 to 40 bushels an acre, oats from 20 to 30 bushels, and tame hay about 1 ton.

Some farms do not have a sufficient area of more desirable land to enable the farmer to avoid cultivating these areas, and for this reason some land is cropped that should not be in cultivation on account of its tendency to erode. Erosion on the slopes is generally of the rapid sheet-wash type, and few gullies form. Small gullies are forming, however, in a few places on the longer slopes leading down to Lime Creek in Grant Township and on similar slopes elsewhere. Most of these gullies can be controlled by a few temporary dams of earth, sticks, and wire, to hold them until grass becomes established; but if gullies are allowed to deepen, more costly measures of control will be necessary. All slopes subject to rapid erosion should be keep seeded to grass. Cover crops of fall rye and sweetclover will prevent washing from loose stubble fields. Soybeans should not be grown, because of their loosening effect on the surface soil. Strip cropping and contour cultivation help in the control of erosion, but many of the slopes on this land are too short and abrupt to allow this system of management.

Liberal applications of manure, growing cover crops, and plowing under green-manure crops and all crop residues aid in improving the physical condition of the soil. The crops respond well to proper treatment, and moderately good yields of the staple crops can be obtained by good management.

Clarion silt loam.—The 14-inch surface layer of Clarion silt loam consists of black mellow silt loam with a high content of organic matter. Below this, and continuing to a depth of 22 inches, is very dark brown moderately friable silty clay loam. At a depth of 28 inches the soil material is yellowish-brown silty clay loam with faint-gray and rust-brown stains. The material in this layer is slightly compact and sufficiently impervious to retard the downward flow of water. The next layer, which continues to a depth of 35 inches, is yellowish-brown silty clay loam containing glacial sand and gravel. It is not so compact as the layer above. Small particles of calcium carbonate are present at a depth of 28 inches. Below a depth of 35 inches is yellowish-brown heavy massive silty clay discolored in many places by rust-brown iron stains and light-gray lime concretions. A few boulders are present on the surface and throughout the soil.

Lime has been leached to a greater depth in Clarion silt loam, especially in gently rolling areas adjoining the Carrington soils, than in Clarion loam, and the surface soil generally is more acid. In small areas where Clarion silt loam is associated with Clarion loam in the western part of the county, the lime content is greater and the soil is less perfectly drained than in the more normal areas. The lime content and moisture conditions of Clarion silt loam range between two extremes, approaching those features of Carrington silt loam, on the one hand, and those of Webster silt loam, on the other. On a smooth upland divide between Lime and Calmus Creeks in Lincoln Township, Clarion silt loam is underlain by sand and gravel at a depth of 4 feet or more. Crops may show slight damage from drought on these areas in exceptionally dry seasons, but in normal years soil moisture is not lacking.

The largest bodies of this soil, representing about four-fifths of its total area, occur in Bath, Mason, Lake, Lincoln, and Lime Creek Townships on the upland till plain, which is bordered on the west by the morainic hills of the drift and on the east by the gently rolling relief of the older Iowan drift.

The surface of Clarion silt loam is very gently rolling over the more eastern areas and is undulating to rolling over the western areas. Natural drainage is good, except where the soil is associated with the Webster soils on nearly flat areas, many of which must be artificially drained before they can be cultivated.

Clarion silt loam is a productive soil, and the greater part has a surface well suited for cultivation. Only a small part is too poorly drained for the growing of grain and tame-hay crops. Very little of the land is devoted to pasture. Corn yields average 45 bushels an acre, with much higher yields in the most favorable seasons; oat yields range from 40 to 45 bushels; mixed timothy-and-clover hay yields average 1¾ tons; clover hay, 2¼ tons; and alfalfa, 2¾ tons. Better stands of alfalfa are obtained on this soil than on the more acid Carrington soils, but applications of lime will increase the yields. The periodic growing of legumes often benefits the yield of succeeding grain crops, although only the stubble ordinarily is plowed under. The regular rotation of legumes with grain crops, together with periodic green manuring, is the most practical supplement to barnyard manure. The nitrogen supply of this soil can be maintained under this system of management more economically than by the use of commercial nitrogen fertilizers.

Clarion fine sandy loam.—The surface soil of Clarion fine sandy loam is dark grayish-brown loose fine sandy loam to an average depth of about 12 inches. This is underlain by dark-brown fine sandy loam, which is slightly heavier in texture than the surface soil. Between depths of 22 and 36 inches is yellowish-brown silty clay loam or clay loam with faint-gray and rust-brown stains. Below a depth of 36 inches the soil material is light yellowish-brown silty clay loam containing spots and streaks of light-gray limy material and rust-brown iron stains. This layer differs from the corresponding layer of Clarion loam in containing pockets or thin veins of sand and gravel, and in a few places it is entirely of a sandy clay texture. At this depth the subsoil contains as much lime as Clarion loam, but the upper layers are generally more completely leached and are more acid. The principal difference between this soil and Clarion loam is the lighter texture of the surface soil.

The areas of Clarion fine sandy loam as mapped include some small unmappable areas of Clarion loam and Pierce loam. Clarion fine sandy loam occurs in a few small scattered areas in the western half of the county, in association with Clarion loam and Clarion loam, rolling phase. The largest body is on the bluffs and slopes adjoining the Lime Creek bottom lands in Grant Township.

The areas of Clarion fine sandy loam are rolling, and most of them occupy ridges and crests of hills and the higher slopes. In general, the slope is greater than that of Clarion loam and less than that of Clarion loam, rolling phase. Natural drainage ranges from good to excessive, and the loss of water in most places is the result of rapid run-off rather than of percolation through the soil.

About two-thirds of the area of this soil is used for the production of cultivated crops, most of the remainder is in pasture, and a small part is covered by hardwood forest and hazel brush. Clarion fine sandy loam is considered a less productive soil than the heavier types of the Clarion series but is more productive than the Pierce and Dickinson soils. Crop yields are slightly lower than on Clarion loam, rolling phase. Clarion fine sandy loam can be cultivated earlier in the spring and matures crops sooner, but its susceptibility to drought and erosion offsets this advantage. This land usually is farmed in conjunction with Clarion loam and its rolling phase, and it requires the same management for maintenance of its productivity.

Dodgeville silt loam.—The surface soil of Dodgeville silt loam is very dark grayish-brown mellow silt loam. Below this, to a depth of 20 inches, is dark yellowish-brown heavy silt loam or silty clay loam, with a higher content of very fine sand than is present in the surface layer. Between depths of 20 and 38 inches is light rust-brown silty clay, which rests on beds of slightly altered limestone, with embedded layers of calcareous reddish-brown clay. The depth of the soil covering over limestone ranges from 1 to 5 feet, and the character of the soil material varies according to the depth of the mantle. The thinner mantle of soil in general is loamy, and, if the areas were large enough to show separately on the soil map, they would be mapped as Dodgeville loam. A deeper than typical mantle of soil with a more silty texture approaches the Carrington or the Tama soils in character. An extensive and unbroken area of this kind occurs in the eastern part of Owen Township. In a few places heavy clay lies immediately beneath the soil, and the limestone occurs below this. An area in section 11 of Portland Township has a substratum of this kind. In another place, in section 1 of Portland Township, the substratum is deep-red limestone, and the soil throughout the entire profile has a red cast.

The largest areas of Dodgeville silt loam are in the drainage basin of Lime Creek; areas are in the drainage basin of Beaverdam Creek in Geneseo Township; and the smaller ones are in the drainage basin of Shell Rock River.

The surface of Dodgeville silt loam is unevenly rolling where the network of intermittent streams is well developed, but it is nearly level on terracelike areas extending back from drainageways, for example, in the eastern part of Owen Township. A few areas occupy preglacial ridges above the till plain, as in section 19 of Portland Township. Natural drainage is inclined to be excessive. Once percolating water reaches the bedrock strata, it is rapidly carried away, both laterally and downward through the rock fractures. On the areas of the deeper soil, however, excellent crops can be produced in most seasons. In the eastern part of Owen Township this land is very productive.

About 60 percent of Dodgeville silt loam is cultivated; about 15 percent is in forest and woodland pasture; and the rest is in pasture and wild hay. This soil can be worked under a wide range of moisture conditions and has excellent physical properties. Crops start and mature earlier on the Dodgeville than on other soils of the county, with the possible exception of the sandy Dickinson soils.

If a high organic-matter content is maintained in the soil, crop yields are better than those obtained on the Carrington soils in favorable seasons, and are only slightly lower as a rule. The management recommended for Carrington silt loam is equally applicable to this soil.

Dodgeville loam.—The surface layer of Dodgeville loam, to an average depth of about 10 inches, is very dark brown friable loam. Below this, and continuing to a depth of 18 inches, is dark yellowish-brown heavy loam. The next lower layer consists of light rust-brown silty clay, which is plastic in the lower part. Below a depth of 24 inches, the soil grades into partly decomposed limestone, which forms a thin covering over the hard bedrock. The total thickness of the soil varies considerably but averages about 2 feet, as compared with 3 feet in Dodgeville silt loam. In places the soil mantle is as much as 4 feet thick. The areas in Pleasant Valley Township are of this kind; whereas narrow strips along the stream bluffs have a shallow soil mantle, in places less than 1 foot thick, with bare rock exposed in spots on the steeper slopes.

More than one-half of Dodgeville loam is in forest and pasture, and the rest is in cultivated crops. It is a soil of low productivity and is not cropped, except on farms that do not have sufficient acreage of soils better suited for farming. Under cultivation it calls for the same methods of management as Carrington silt loam, with added emphasis on methods of storing moisture and the control of erosion.

Tama silt loam.—Although Tama silt loam occupies only 6.3 square miles in this county, it is considered one of the better agricultural soils. Owing to the mellow consistence and uniform silty texture, it is particularly easy to maintain in good physical tilth under cultivation. The surface soil is dark grayish-brown or almost black mellow silt loam, having an average depth of about 15 inches, underlain by slightly lighter colored and heavier textured silt loam. At a depth of 22 inches the material is moderately dark brown heavy silt loam or silty clay loam, and at a depth of 34 inches it gives way to lighter yellowish brown silty clay loam with faint rust-brown and gray stains. The slightly altered calcareous Iowan till lies 4 feet below the surface. The reaction generally is medium to strongly acid in the topmost 2 feet and slightly acid from that depth down to the Iowan till.

In Cerro Gordo County, Tama silt loam closely resembles Carrington silt loam, as the Iowan till underlies both these soils. Tama silt loam, however, has a siltier texture and a smaller content of sand. The surface soil of Tama silt loam, especially where it adjoins the Dodgeville soils, is browner in dry plowed fields than the surface soil of Carrington silt loam.

Tama silt loam is comparatively uniform in the upper 3 feet throughout its occurrence. Along many road cuts the line of demarcation between the silty upper soil and the heavy stony Iowan till can be plainly traced as a horizontal line. In a few places, adjacent to areas of Dodgeville soils, limestone occurs below the till at a depth of 5 feet.

About one-half of this soil is in one area south of Beaverdam Creek in Geneseo Township. In sections 5 and 14 of Owen Township small areas with a lighter brown surface soil and a limestone substratum approach Dodgeville silt loam in appearance and productivity.

The surface of Tama silt loam ranges from undulating to rolling. This soil occurs on the upland bordering the larger valleys in association with the Lindley and Dodgeville soils, where it invariably occupies the smother surfaces back from or capping the stream bluffs.

Natural drainage is as desirable as that of any soil in the county. Compared with other soils, this soil has a greater capacity for absorbing and retaining moisture without becoming too wet, and in addition it has a favorable physical condition over a wide range of moisture content.

Nearly all of the area of Tama silt loam is cultivated. Small bodies that occur within fields consisting largely of Lindley or Dodgeville soils are kept in pasture or woodland. General yields of farm crops are similar to those on Carrington silt loam. Methods of cultivation and improvement recommended for Carrington silt loam apply equally well to Tama silt loam.

Lindley loam.—Lindley loam is the only soil in this county having a light-colored surface soil. The color is the result of development under the influence of a forest vegetation, which grows on slopes along the streams and lakes.

The 9-inch surface soil of Lindley loam is light grayish-brown friable loam. It is underlain, to a depth of 18 inches, by grayish-yellow heavy loam or silt loam. Between depths of 18 and 30 inches is light yellowish-brown silty clay loam stained with rust brown and gray and containing glacial sand and gravel. Below this is yellowish-brown stiff clay or fine sandy clay, containing glacial gravel and a few boulders. The soil rests, at a depth of 62 inches, on slightly altered Iowan till, which is somewhat calcareous and generally less compact than the sandy clay of the layer immediately above. This soil differs from Carrington loam mainly in the lighter colored surface layer and the more compact subsoil.

Areas of Lindley loam include several minor variations. A silt loam surface soil occurs in section 25 of Bath Township and section 6 of Falls Township. About 10 percent of the total area of Lindley loam is of this character. These areas are considered slightly more productive than typical Lindley loam, as the surface drainage and internal drainage are more favorable for the production of crops. The area in section 31 of Portland Township has sandy material within the profile. The greater part of this area is too thickly wooded to furnish good pasture. Underlying layers that are less uniformly sandy occur in cultivated areas of Lindley loam in section 16 of Falls Township. The uplands south of Blair Creek have a surface soil slightly darker than that of the typical soil, and lime is nearer the surface.

About three-fourths of Lindley loam is in forest or woodland pasture, and the rest is in cultivated crops. Most of the cultivated areas are associated with more productive soils. Yields obtained without the use of fertilizers generally are low, but the soil is responsive to good management. The best use for this soil is forestry or woodland pasture, especially where sufficient acreages of the more productive soils occur on the farms for the cultivated crops.

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Waukesha silt loam.—The surface layer of Waukesha silt loam is finely granular very dark silt loam about 14 inches thick. It is underlain by moderately dark brown silty clay loam. Between depths of 28 and 39 inches is yellowish-brown silty clay loam with a sand content that increases with depth. Below a depth of 39 inches is yellowish-brown sandy clay loam containing coarse sand and gravel. The soil is medium acid to a depth of 2 feet and slightly acid below that.

The surface soil in places is more nearly a loam than a silt loam, but this slight difference in texture has little effect on productiveness. An area with a loamy texture occurs in section 34 of Bath Township. An area in section 1 of Lime Creek Township, on a terrace below areas of Lindley loam, has a lighter colored surface soil than is typical. In section 36 of Portland Township, spots of shale clay are exposed. Except for these few variations the soil has a mellow dark-colored surface soil and a yellow-brown heavier subsoil. The soil closely resembles Carrington silt loam but differs from that soil in that it occupies terraces and has developed on a parent material of alluvium instead of glacial till.

The surface of Waukesha silt loam is level to gently sloping and lies well for cultivation. The soil occupies benchlike stream terraces that are not subject to overflow. The higher parts of these terraces grade into gently sloping upland areas, and some of the bodies in Falls Township merge almost imperceptibly with the uplands. Natural drainage is good but not excessive. The heavy subsoil has a capacity to store moisture, so that crops seldom suffer damage from drought.

A larger proportion of the area of this soil is in harvested crops than of any other soil in the county. Occurring as it does on terraces, this is considered excellent land for general farming. Only very small parts of it are used for pasture. Yields are equal to or higher than those obtained on Carrington silt loam. The same practices that are recommended for the improvement of Carrington silt loam can be applied to Waukesha silt loam.

IMPERFECTLY AND POORLY DRAINED SOILS

This group includes soils in which, as a result of their flat surface or low topographic position, the water table is at or near the surface, at least a part of each year. When this section was first occupied by farmers, all these soils were poorly drained and a large part of the land was covered by standing water during a part of the year. The rather intensive system of cultivation, formerly limited to the upland soils, has been possible on this land only during the last 25 years, that is, since drainage systems were constructed. Artificial drainage by means of ditches and tile now removes the surface water rapidly enough for crops to be grown on the naturally poorly drained soils of the uplands and terraces without damage, except in unusually wet seasons. The soils of the stream bottoms are for the most part still undrained, but some of them may be converted into valuable farm land by proper drainage.

This group of imperfectly drained soils includes 20 soil types belonging to 10 soil series. The characteristics common to these soils and those that distinguish them from the other soils of the county are their poor natural drainage and the internal characteristics due to excessive moisture. The surface layers are nearly black, because of the large quantities of black organic matter produced by the former luxuriant grass vegetation. They contain more organic matter than the better drained soils of the county, and the presence of this material imparts a black color. In places, a large amount of decayed vegetation has accumulated on the surface and has formed muck or peat. The high content of organic matter is decreasing under cultivation, as a result of the mixture, by plowing, of the organic material with the mineral soil below.

As a rule, the texture of the soils of this group is heavy, ranging from heavy loam to silty clay, although lighter textured materials do occur in many places. Under favorable moisture conditions even the heavier soils have a crumbly granular structure and are easily tilled. The surface soils of the members of this group are underlain by gray or mottled gray and yellowish-brown subsoils that are somewhat heavier in texture, as a rule, than the surface soils. The character of the underlying materials varies according to the kind of parent material from which the soils were developed and the depth to which oxidation and leaching have been effective. Some of the soils are leached of their lime to a depth of several feet, and others are highly calcareous. The Webster, Fargo, Benoit, and Lamoure soils have retained enough lime to effervesce with acid within 3 feet of the surface. The soils of the Floyd, Bremer, Clyde, and Wabash series have been leached of their lime and other carbonates to a depth of more than 3 feet.

The most extensive of the immature soils of the county are members of the Webster series, represented by the silty clay loam, silt loam, and loam. These soils occur in flat areas where natural drainage is poor, but most of the areas are now artificially drained and are highly productive. The parent material of these soils is calcareous glacial till. The Floyd soils have a relief similar to that of the Webster soils, but they are developed from an older till, so that the lime and other carbonates are leached to a depth of several feet. The Clyde soils occupy poorly drained stream valleys, swales, and depressions, in which a thin covering of alluvium overlies glacial till. The Benoit, Fargo, and Bremer soils occupy terraces, and the Wabash, Lamoure, and Cass soils occupy first bottoms. The Millsdale soils are underlain by limestone.

Webster silty clay loam.—The surface soil of Webster silty clay loam, to an average depth of 17 inches, is black silty clay loam. In the virgin soil the 3-inch surface layer is filled with grass roots, forming a turf. The structure of the surface soil is finely granular, but the granules are not distinct, and loose silt is present in the dry soil. This layer is underlain to a depth of about 24 inches by plastic silty clay loam or silty clay. The dark-gray color predominates, but light-gray spots and streaks are common. Small glacial gravel and boulders are commonly abundant in this layer. Although alkaline in reaction, calcium carbonate is not everywhere present in this layer in sufficient quantity to effervesce with acid. The next lower layer, which continues to a depth of about 32 inches, consists of grayish-yellow or gray, mottled with light gray or yellow, silty clay loam. Lime is abundant both in disseminated form evenly distributed through the material and in small soft concretions. Small glacial boulders and pebbles occur in this layer, which is the glacial till or soil parent material. Below this, and continuing to a depth of more than 6 feet, is highly mottled gray, brown, and yellow glacial till. Small iron concretions are present, and iron stains discolor more than half of this material. Lime is abundant in this layer, in much the same form as in the layer above The material has a silty clay texture and is plastic.

The largest areas of Webster silty clay loam are on flat areas in the southern part of Lake Township and the western part of Union Township. These low flat areas are irregular in shape and form an intricate pattern with the areas of Clarion soils. Smaller areas of this soil occur in the southern part of Lincoln Township, southwestern part of Grimes Township, and elsewhere over the Wisconsin till plain, which covers the western half of the county. This soil does not occur in the eastern tier of townships.

Webster silty clay loam has developed from calcareous till of the Wisconsin glaciation, in positions of restricted natural drainage. The native vegetation was a rank growth of bluestem on the better drained areas and sloughgrass in the more poorly drained areas.

Natural drainage on Webster silty clay loam is deficient, and for profitable production of crops, tile and open-ditch drainage systems are necessary. Natural drainage on the flat tableland areas is better established than on the lower areas and in years of light precipitation may be adequate for the production of crops. Depressed areas, which receive some surface water from the surrounding high ground, lack adequate natural drainage, but where well drained artificially, they may be kept in good tilth if the soil is not worked too soon after rains. The subsoil holds a large amount of water, and tile drains must be laid at intervals close enough to drain off the surplus. During the longer dry periods, deep cracks form in the surface soil, and the soil becomes baked to an extent that may cause some damage to crops. Intermittent freezing and thawing during the winter causes the soil to heave, which results in the winter-killing of clover, alfalfa, and sweetclover.

About 55 percent of this soil is in cultivated crops, and 45 percent is in pasture and hay crops. Most of the pasture and wild hay is grown on the narrow lowland strips, and these areas provide grazing during parts of the dry summers when pastures on the higher land fail. Webster silty clay loam produces good yields of the staple grain and hay crops. It is highly prized for growing corn, and the tendency is to crop it continuously to corn, yields of which range from 25 to 80 bushels an acre, with an average of about 48 bushels. The low yields occur in about 1 out of 5 years, when the season is too wet or too short to allow proper maturity of the grain. Oats yield from 40 to 60 bushels an acre, but in wet seasons yields are lowered by excessive growth of straw, with an accompanying loss from lodging and rust. Therefore, a stiff-strawed variety of oats is best for this soil. The yield of clover-and-timothy hay is about 2 tons an acre, and alfalfa produces from 2 to 4 tons. This is one of the best soils in the county for the production of sugar beets, which yield about 12 tons an acre.

This soil is very productive, but the use of manure, the plowing under of crop residues, and the use of a legume in the crop rotation are desirable for the maintenance of productivity at a high level. Where well drained and carefully managed, the soil produces as well as or better than any other soil in the county. Legumes do well, as a rule, because of the high content of lime. In a few places, however, the surface soil is acid, and new seedings will do better if the soil is first treated with lime. Crops sometimes show a response to applications of phosphate fertilizer, but trials with it on individual farms are advised. Large applications of manure are not necessary and may even be harmful if they are made prior to the growing of the small-grain crops, as the loss from lodging will be greater. Incorporation of manure and crop residues into the plow layer aids greatly in reducing the puddling that may result when the soil is worked while wet. Flax frequently is sown on this soil to improve the physical condition for grain cropping, but the benefit is temporary where the underdrainage is not adequate. In the lowland strips, small spots of the so-called alkali condition develop, which must be corrected, in addition to improvement of the drainage.

Webster silt loam.—The surface soil of Webster silt loam is black smooth silt loam, with an average thickness of 15 inches. The upper 6-inch layer is friable silt loam, but below this the material is less friable and slightly heavier in texture. Between depths of 15 and 23 inches the soil material is dark grayish-brown silty clay loam, being more brown and less gray than the second layer of Webster silty clay loam. The next lower layer is olive-gray plastic silty clay loam mottled with rust-brown iron stains, white concretions due to lime, and a few streaks or spots of dark organic stains. Below a depth of 34 inches is heavy plastic silty clay that is grayer than the material in the layer above and lacks organic stains, although it is highly mottled with iron and concretionary lime. With depth this material grades into the calcareous till of the Wisconsin glaciation. The upper two layers generally are leached and have a neutral to slightly acid reaction. In places they are alkaline, owing to the presence of finely divided lime throughout the soil mass. The lower layers contain pebbles and small boulders, and a few boulders are scattered over the surface.

This soil is very uniform over the larger areas on the level part of the upland plain, but in the narrow lowland strips, which serve as beds for sluggish intermittent streams, soil washed from nearby slopes has accumulated to form a deeper black surface layer. In the network formed by these lowland strips among the more elevated sites occupied by the rolling phase of Clarion loam, in the western part of Mount Vernon Township and southeastern part of Union Township, the texture of the surface soil is modified in places by a coating of loamy sediment washed from the higher land. In the wetter areas, the mineral soil is covered by a thin layer of muck. On the eastern edge of the Wisconsin till plain the adjoining soil on the higher, better drained positions is Clarion silt loam, and here the surface soil is a smoother silt loam than in areas adjoining Clarion loam. In the northwestern part of Geneseo Township and parts of Bath Township, Webster silt loam has a lower content of lime and is more deeply leached, somewhat resembling Floyd silt loam. Another variation, occurring in a few places, has thin veins of sand or gravel in the lower part of the profile. An area of this kind is in section 5 of Bath Township, in association with Benoit silty clay loam. In places, generally in depressed positions where alluvial materials have accumulated, the subsoil has a uniformly mottled gray color and is very calcareous. In association with Clarion loam, the surface texture in small areas ranges from silt loam to clay loam; and in association with Clarion silt loam it approaches silty clay loam in places.

Webster silt loam occurs mainly in Mount Vernon, Union, Grimes, and Bath Townships, and the largest areas are on the level parts of the upland plain in these townships. Webster silt loam has been developed over the calcareous till of the Wisconsin glaciation in places where natural drainage has been restricted. A sod of bluestem grasses was common on most of this soil, with a mixture of sloughgrasses in the more poorly drained places.

The land is flat to very gently undulating, and natural drainage is fair to poor. Although some areas need little improvement, most of them require tiling before they can be satisfactorily farmed, and only a few areas are not benefited by tiling. Favorable seedbeds can readily be prepared if the soil is not worked when too wet. Plowing under crop residues and applying moderate quantities of manure are an aid in maintaining good tilth. As a first crop after artificial drainage, flax has a beneficial effect on the seedbeds for the following crops of corn, small grains, and hay.

Tile laid in the subsoil draws off the surplus soil water readily, and waterlogged conditions do not last long enough after rains to retard crop growth. During the longer dry spells some damage may be done to crops from the baking and cracking of the surface soil, and stands of clover may be injured by winter-killing in spots where the soil is cracked and heaved by intermittent freezing and thawing.

About 60 percent of this soil is in cultivated crops, and 40 percent is in pasture and hay. Like Webster silty clay loam, it is productive of the staple grain and hay crops and is highly prized for corn. It is more continuously cropped to corn than soils of the well-drained group, such as the Clarion and Carrington soils. Corn yields range from 30 to 80 bushels and average about 50 bushels an acre. The low yields occur in about 1 out of 5 years, when the season is too wet or too short to allow proper maturing of the grain. In such years yields are not reduced quite so much on this soil as on the heavier silty clay loam. Oats yield from 40 to 60 bushels an acre. As on the silty clay loam, the low yields of this crop occur in wet years, when the crop is damaged by lodging and rust. A stiff-strawed variety of oats is best adapted for this soil. Webster silt loam is one of the soils selected for growing sugar beets, and acre yields of 10 or 12 tons are obtained. Clover and timothy produce 1½ to 2 tons of hay, and alfalfa from 2 to 4 tons an acre. Most of the pasture and wild hay is on the narrow lowland strips that are too poorly drained for cropping. These pastures are more resistant to drought during the occasional dry spells than are pastures on the well-drained soils, and to some extent they supplement those pastures. Because of its productivity, this soil is used almost exclusively for corn by some farmers.

Where this soil is to be cultivated, poor drainage must first be corrected by tiling, and thereafter care must be exercised, so that poor tilth is not caused by stirring the soil when too wet. The plowing under of manure improves the physical condition of the surface soil, and crops respond to the available plant food it furnishes. If manure is applied just prior to the growing of small grains in the rotation, however, greater losses from lodging and poorly filled heads will result. Where the upper layers of the soil are acid, applications of lime will benefit new seedings of legumes, but otherwise the soil contains sufficient lime for a good growth of these crops. Many experiments with phosphate fertilizer have shown increased crop yields, but trials of such fertilizer are advisable before making general applications.

Webster loam.—The 5-inch surface layer of Webster loam is very dark grayish-brown loam. It is underlain, to a depth of 12 inches, by very dark grayish-brown heavy silt loam. The layer between depths of 12 and 25 inches consists of dark grayish-brown plastic silty clay loam. The next lower layer consists of an olive-gray plastic silty clay loam, with rust-brown iron stains, some dark organic stains, and light-gray lime concretions. Below a depth of 35 inches the soil material is heavy plastic grayish-yellow or gray mottled silty clay. This grades, with depth, into the highly mottled gray, rust-brown, and yellow calcareous till of the Wisconsin glaciation. The lower soil layers contain pebbles and small boulders. Ordinarily, calcium carbonate is absent in the upper two layers but is abundant below a depth of 25 inches.

Small areas mapped as Webster loam show some variations from place to place. In the narrow lowland strips within the plain occupied by the rolling phase of Clarion loam in Grant Township, the surface soil of Webster loam ranges from 5 to 14 inches in thickness. In places, the topmost 5-inch layer is light mucky loam. The surface soil is thickest where soil has been washed down from areas of higher land, as in section 13 of Grant Township. Where this soil occupies small areas slightly higher than the surrounding areas of Webster silty clay loam, the texture is clay loam. Areas of this kind occur in section 28 of Lake Township, and sections 30, 31, 32, and 33 of Grant Township. A small area in section 30 of Lincoln Township, which is slightly elevated above Fargo silty clay loam and adjacent to an area of Benoit soil, has layers of sandy material in the subsoil, but these are thin, and the subsoil contains other layers that are heavy and poorly drained. On the edges of these slightly elevated areas, white coatings show on the surface.

Webster loam occurs only in very small scattered areas, either in narrow lowland strips or slightly elevated islands, within areas of heavier Webster or Fargo soils. Nearly half the acreage of this soil is in Grant Township. It does not occur in the eastern half of the county.

Webster loam has been formed from the calcareous till of the Wisconsin glaciation in places where natural drainage has been restricted. The loam surface soil, in places, has been formed in part by sandy wash over heavier textured material.

The surface of Webster loam is flat to very gently undulating, and natural drainage is fair. The small areas occupying slight elevations above flats of heavier soils in few places are tapped by tile laid in the heavier soil, unless these silts contain salts that must be removed. Where the loam is thick, underdrainage is not necessary to maintain good tilth, but a heavy layer near the surface prevents removal of water by percolation. It must then be removed by tiling, in order to insure crops in wet years.

Webster loam has a high content of organic matter and is productive. Although the surface soil, with its larger content of sand, can be worked somewhat more easily than the silt loam, it still requires careful management, and the recommendations for Webster silt loam apply equally well to this soil.

About 50 percent of Webster loam is in cultivated crops, and 50 percent is in pasture and hay. Small areas of this soil are not large enough to justify a special type of management, and they are farmed with the areas of soil surrounding them. Webster loam is capable of producing about the same crop yields as Webster silt loam.

Floyd silt loam.—Floyd silt loam occurs at the heads of draws, or on areas of almost imperceptible slope, intermediate in position between the Clyde soils near the drainageways and the Tama and Carrington soils on the higher land.

The surface soil of Floyd silt loam is very dark grayish-brown or black mellow silt loam having an average thickness of about 6 inches. Below this, and continuing to a depth of 15 inches, the soil is heavier in texture, being a heavy silt loam or silty clay loam, which is more sticky when wet. This is underlain by dark-brown plastic silty clay loam stained with rust brown and gray. Between depths of 27 and 40 inches, the soil material is yellowish-brown stiff silty clay mottled with rust brown, yellow, and gray. It is somewhat compact in place but is moderately permeable to percolating water. This is underlain, to a depth of 54 inches, by brown heavy silty clay loam, more highly mottled with rust brown, gray, and yellow than the layer above and in many places containing thin bands of sand and pebbles. The material in this layer is nearly neutral, whereas the overlying material ranges from medium to strongly acid. Below a depth of 54 inches is the till, which consists of yellow, brown, and gray mottled stiff silty clay and contains glacial gravel and boulders and finely divided lime.

Most of Floyd silt loam has the profile described above, but there are some variations. One includes numerous small areas that have thin beds of sand within the profile. These spots are widely distributed over the areas mapped as Floyd silt loam, and the veins of sand under the heavier layers apparently do not improve the drainage conditions. On the undulating till plain in the northeastern part of Falls Township the black surface soil is thicker than typical, in many places reaching a thickness of 24 inches. In the northern part of Portland Township a rather large area is underlain at a slight depth by preglacial shales and limestones. The weathered products of the older rocks, either weathered in place or mixed with the till, impart a heavier and more impervious character to the subsoil.

Floyd silt loam is developed from Iowan till, which is also the parent material of the Carrington and the Clyde soils. The differences between the soils of the three series have been produced by differences in relief and resultant drainage conditions during their development. The surface soils of members of the Floyd series are darker and deeper than those of the Carrington soils, but not so black and deep as those of the Clyde soils. The underlying layers of the Carrington soils are brown, mellow, and well oxidized, and a little heavier in texture than the surface soils. The Clyde subsoils, on the other hand, are heavy in texture and gray or mottled, showing evidence of very poor drainage. The Floyd subsoils are only moderately mottled, are heavy in texture, and do not, like the Clyde subsoils, show the influence of permanently excessive moisture. The Floyd soils are similar to the Webster soils, but they were developed on an older and more deeply leached till. They contain no calcium carbonate within 4 feet of the surface, whereas the Webster soils are developed from calcareous glacial till and contain lime at a depth of 30 inches or less.

The largest areas of Floyd silt loam are in Owen, Bath, Dougherty, Falls, and Geneseo Townships. The soil occupies level or gently sloping areas below higher slopes or crests of divides, on which the Carrington soils are developed, and above the depressions or poorly drained swales occupied by the Clyde soils.

Natural drainage of this soil is only fair, and, although much of the land can be farmed without tiling, the best crop yields cannot be obtained without some improvement in drainage. Drainage is not so poor and tiling is not so costly as in the Clyde and Webster soils. The run-off of rain water on the slight slopes is slow, and most of the water is absorbed. Generally, water percolates downward at a satisfactory rate, so that field work need not be postponed quite so long after rains as on the Webster and Clyde soils. The areas of Floyd silt loam that have a heavy clay subsoil drain much more slowly, and tile drains should be placed at smaller intervals, in order to provide proper underdrainage. Floyd silt loam cannot be cultivated so soon after rains as can the Carrington soils.

About 70 percent of Floyd silt loam is in cultivated crops, and 30 percent is in pasture and hay. It is a highly prized soil for corn and is cropped more continuously to corn than to small grains and hay. Corn yields average about 50 bushels an acre and range from 25 to 80 or more bushels. The low yields occur in about one out of five seasons, which have too wet or too short growing periods for the grain to mature properly. Oats yield from 40 to 60 bushels an acre, the lower yields being obtained in the wetter seasons, when the crop suffers losses from lodging and rust. A stiff-strawed early-maturing variety of oats is best adapted to this soil. Clover-and-timothy hay yields about 2 tons an acre. Excellent stands of alfalfa, producing 2½ or 3 tons an acre, are obtained, provided the land is not too poorly drained or too acid. This is one of the soils selected for growing sugar beets, which yield about 10 tons an acre on it. Most of the pasture and wild hay occupy areas where drainage is poor. This soil will produce excellent grass, but when well drained it is commonly used for corn.

Applications of manure, plowing under of crop residues, and seeding to legumes in a systematic crop rotation are beneficial. In a normal season with well-distributed rainfall, this soil can be worked easily and kept in good tilth, but in wet seasons it presents much

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the same difficulties of tilth as the Clyde and Webster soils. When in poor tilth the surface soil may bake and crack during dry periods and allow drought to damage the crop. During winter freezing and thawing, the cracking and heaving of the soil may cause winter-killing of legume crops.

Floyd silty clay loam.—The 14-inch surface soil of Floyd silty clay loam is black silty clay loam, which is somewhat plastic when wet but friable when dry. The topmost 2- or 3-inch layer is more friable than the lower part. Below this, and continuing to a depth of 23 inches, is dark grayish-brown silty clay, which is heavy and sticky when wet. The next lower layer is somewhat puttylike silty clay. Below a depth of 31 inches is heavy compact silty clay containing glacial sand and pebbles. The material is dominantly brown, streaked with gray, yellow, rust brown, and black. It rests, at a depth of 47 inches, on brown or olive-brown heavy boulder clay or shaly clay, highly stained with iron and containing specks of concretionary lime. This material is the little altered Iowan till, with some decomposed shale mingled with it. The first three layers of soil, from the surface downward, contain no calcium carbonate and are neutral to medium acid. Finely divided lime may be present below a depth of 36 inches, but concretionary lime is not present above a depth of 48 inches.

Floyd silty clay loam lacks the well-oxidized subsurface layer common to Floyd silt loam, but it has the typical compact layer in the subsoil, which is one of the main distinctions between the Floyd and the Clyde soils. Floyd silty clay loam differs from Webster silty clay loam, both in its lower lime content and its more compact subsoil layer.

This soil is developed chiefly in Portland Township on that part of the Iowan till plain that has a shallow soil mantle over compact boulder clay. Smaller areas are in Falls, Lime Creek, and Lincoln Townships.

The surface of Floyd silty clay loam is, in general, flat or gently sloping, and in a few places it is slightly depressed. This soil commonly occurs on slopes intermediate between higher lying Carrington soils and Floyd silt loam and the Clyde soils in the lower depressions. Areas in sections 13 and 14 of Portland Township are on level flat upland divides; those in section 23 of Falls Township are on low flat uplands below the divide; and those in section 24 of Portland Township occupy slopes between the Carrington and Clyde soils. Natural drainage of Floyd silty clay loam is slightly less efficient than that of Floyd silt loam but is not so poor as that of the Clyde soils.

Floyd silty clay loam has been formed on those parts of the Iowan till that consist of tight boulder clay or shaly clay. Natural drainage has been restricted, and the growth of prairie grasses has been vigorous.

This soil was formerly too wet for cropping, but the underdrainage of much of it has been improved by tiling. For adequate underdrainage the tile lines must be laid closer together than in the Webster soils, because the subsoil is tighter and holds the water away from the tile. More of the silty clay loam than of the silt loam is inadequately drained for cropping.

About 65 percent of Floyd silty clay loam is in cultivated crops and 35 percent in pasture and hay. This is a heavy black soil, such as is prized highly for corn, but it is considered too heavy and too hard to keep in good tilth under continuous grain cropping, unless a considerable outlay is made for tiling. Once improved, Floyd silty clay loam produces about the same yields of crops as Floyd silt loam, and the same practices are necessary to maintain its productivity.

Clyde silty clay loam.—The surface soil of Clyde silty clay loam, to an average depth of about 16 inches, is black silty clay loam. The upper 6 inches of this layer is slightly less friable than the lower part and when wet is very plastic. The surface soil is underlain by dark grayish-brown or almost black silty clay. Between depths of 22 and 30 inches, the material is brown or olive-brown plastic silty clay with mottlings of rust brown, gray, or yellow, and below this it is more mottled and contains many rust-brown iron stains. Glacial sand, gravel, and boulders, which occur in small quantities in the layers above, become more abundant in this layer. Below a depth of 40 inches, the soil is underlain by the slightly altered Iowan till, which consists of clay with a varied content of gravel and boulders. Lime in finely divided form is present in places at a depth of 40 inches, and it occurs as concretions at a depth of 4 to 5 feet. When the land was first settled, glacial boulders, mostly granitic, ranging from a few inches to more than 4 feet in diameter, were scattered over the surface. Most of the boulders have been removed from the cultivated fields.

Near the center of some poorly drained areas of Clyde silty clay loam are small patches, ranging from 30 to 60 feet in diameter, which are covered by muck to a depth ranging from 1 to 5 inches. These are too small to indicate on the soil map that accompanies this report. In other small areas, salts, commonly called alkali, are concentrated in sufficient quantity to injure crops. Other variations in the profile are found where thin layers of either sand or heavy clay occur at depths ranging from 2 to 4 feet. The spots underlain by sandy layers are most numerous around the headwaters of Coldwater Creek in the northwestern part of Dougherty Township. The spots of clay in the subsoil are most abundant in sections 2 and 13 of Portland Township, section 6 of Mason Township, and section 34 of Falls Township. The layers of sand or clay in the subsoil, as a rule, are either too thin or too far from the surface to have a marked effect on drainage. In a few places, spots of sand having the characteristics of quicksand are near the surface and may bog down farm implements or animals. Such an area occurs in section 34 of Owen Township. In other places sandy veins bring seepage waters to the surface and make drainage difficult.

Clyde silty clay loam is developed from glacial till under conditions of excessive soil moisture. As the soil occupies stream valleys, swales, and depressions, a small quantity of sediment washed from the higher land is deposited over the surface. The glacial boulders exposed on the surface indicate that the covering of alluvium is thin. A rank growth of prairie grasses and sloughgrasses has contributed to the large content of organic matter.

In most places the surface of Clyde silty clay loam is flat or slightly sloping, and in some places it is depressed. Because of its low position and its heavy texture, natural drainage of this soil is poor. The greater part of the soil is too poorly drained for successful production of crops unless drainage is improved by tiling. Enough tile must be laid to take care of the run-off water from slopes of the adjacent higher land in addition to rain falling directly on the soil. Areas receiving large amounts of run-off water cannot be adequately drained except by the construction of a general drainage system cooperatively managed for an entire drainage basin. Where district drainage systems have tapped Clyde silty clay loam, a considerable part of the land is in cultivated crops; but, with such improvements of drainage as can be made on the individual farm, only a small part of the soil can be drained for cultivation, and the greater part is used for pasture and hay land.

About 28 percent of Clyde silty clay loam is in cultivated crops and 72 percent in pasture. Where a farm has better drained soils, on which cultivated crops can be grown, the areas of Clyde silty clay loam can be used to good advantage for pasture. Pastures on this soil support a firm sod free from the seepy and hummocky spots, which are seen on many of the Clyde soil areas elsewhere.

Where this soil has been adequately drained it is very productive. It is particularly suited for corn, and yields average between 45 and 50 bushels an acre. In wet years, when this soil remains too moist for spring planting and frost comes before the grain has matured, the yield may be cut to 20 bushels of poor quality corn. In such unusual years the corn sometimes is cut for fodder. In more favorable seasons, acre yields of 80 bushels or more of corn of excellent quality can be obtained. Oats yield about 40 bushels an acre, and in favorable seasons the yield is more than 60 bushels. In wet years when the straw grows too rank and yields are reduced by lodging or the poor filling of the heads, the yields may be less than 20 bushels. A stiff-strawed early-maturing variety of oats is best suited for use on this soil. Clover and timothy hay yields from 1 to 2½ tons an acre. Sweetclover and alfalfa tend to produce a rank growth, which is somewhat difficult to cure for hay.

Adequately drained areas of Clyde silty clay loam are adapted to rotations including legume and green-manure crops, and these are necessary to maintain high productivity. The plowing under of crop residues and applications of manure materially improve the physical condition of the soil.

Clyde silt loam.—The surface soil of Clyde silt loam is black silt loam about 8 inches thick. It is lighter in texture than Clyde silty clay loam and is, therefore, more easily maintained in good tilth. Below the surface layer, to a depth of 20 inches, is black silty clay loam that is moderately plastic and less friable than the surface layer. The next lower layer, which continues to a depth of 30 inches, consists of dark grayish-brown heavy plastic silty clay mottled with rust brown, yellow, and gray. This material gradually changes, below a depth of 30 inches, to slate-gray silty clay highly mottled with rust brown and yellow. This layer contains a considerable quantity of glacial sand and gravel. In most places, below a depth of 40 inches there is a more gritty silty clay loam, which becomes more highly mottled with depth. The slightly altered Iowan till is reached below a depth of 48 inches. This material contains concretions of lime in places, but the soil above lacks lime and is about neutral in reaction. Clyde silt loam has a thicker black surface soil and a less compact more poorly drained subsoil than Floyd silt loam. A few boulders are present in the soil and on the surface.

Variations from the typical soil occur along the Dougherty sand ridge in section 28 of Dougherty Township. The texture approaches a loam in some places, and in a nearby lowland strip the soil is heavy silt loam or silty clay loam, but it has better drainage and the crop adaptations of typical Clyde silt loam. The broader areas of this soil in the eastern part of Falls Township have a dark surface layer, which, in places, reaches a depth of 3 feet. Areas in section 16 of Dougherty Township and section 32 of Owen Township have sandy layers in the lower part of the profile, which either occur at too great a depth or are too thin to improve drainage. Where the sandy layers are thicker and lie within 3 feet of the surface, the soil is mapped in the Benoit series rather than in the Clyde series.

Clyde silt loam occupies numerous small low areas within the Iowan till plain in the eastern part of the county, especially in Falls and Dougherty Townships. Most of the areas are less depressed and are better drained than Clyde silty clay loam. A few areas border depressions on the outer edges of terraces, such as the area in section 1 of Lake Township.

About 38 percent of Clyde silt loam is used for growing cultivated crops, and 62 percent is in pasture and hay land. Crops on adequately drained areas return slightly higher yields than they do on Clyde silty clay loam. The cultural and cropping practices and methods of improvement given for Clyde silty clay loam apply equally well to Clyde silt loam.

Benoit silt loam.—The 13-inch surface layer of Benoit silt loam is black friable silt loam containing considerable sand. Below the surface layer and continuing to a depth of 20 inches, is dark grayish-brown or black silty clay loam with slight iron stainings. When dry the material in this layer has a distinct gray cast, indicating its poor state of oxidation and drainage. The next lower layer continues to a depth of 27 inches. It consists of yellowish-brown light sandy clay loam, which is loosely coherent when dry. This is underlain by loose yellowish-brown stratified sand and gravel. Limestone gravel and other gravel coated with lime are present in this layer, but the upper soil layers may range from slightly acid near the surface to neutral or alkaline below. The gravelly material continues to a depth of several feet, with no heavy-textured material except in thin veins and pockets.

In a few of the poorly drained spots the soil may be mucky in the upper 4-inch layer. A few areas of soil mapped as Benoit silt loam may approach a silty clay loam in texture. Such areas occur in section 28 of Lake Township and sections 33 and 34 of Bath Township. The lower soil layers, in most places consisting of gravelly sand, may become thinner and somewhat heavier in texture in the areas along the upland drainageways. The areas in section 32 of Mason Township and section 5 of Bath Township are of this character where they grade into the adjacent Webster and Clarion soils.

The porous subsoil, in places, is composed of sand that is relatively free from gravel and lime. The areas below a sand ridge in sections 29 and 32 of Dougherty Township have a sandy subsoil, which is kept more or less wet by seepage waters from the ridge. In general, the profiles in areas associated with the O'Neill soils of the terraces have a lower lime content than those adjoining areas of the Sioux soils.

One variation of this soil covers about one-third of the total area mapped. It is characterized by soil layers that are slightly thicker and somewhat heavier in texture than they are in the typical soil. As a rule, the upper layers of fine-textured materials do not differ in color from those of typical Benoit soils. The soil is less permeable, however, and the movement of water through it is somewhat slower. The bed of coarse sand and gravel is nowhere less than 35 inches below the surface and in many places is several inches deeper. In places these gravel layers are thin and are underlain by layers of loam or clay. This variation occupies terraces of the larger streams, depressions which were former ponds in the upland, and shallow drainageways extending into the upland. It occurs mainly in Lime Creek, Bath, and Portland Townships. The area in section 7 of Dougherty Township is the bed of a former pond now drained and farmed. The sand and gravel materials are not composed so largely of limestone, as in typical Benoit silt loam, but most of the coarser material is coated with lime.

The largest areas of typical Benoit silt loam are in Pleasant Valley, Mount Vernon, and Lincoln Townships, on terraces at the margin of the Wisconsin till plain. About one-fourth of the acreage of this soil is in the eastern half of the county on the lower stream terraces.

The surface of Benoit silt loam is flat or slightly depressed. The areas occupy terraces at various levels, mainly back terraces adjacent to the O'Neill soils. In a few places this soil occupies the front of a low terrace, such as the area along Blair Creek in section 4 of Lime Creek Township. Benoit silt loam is developed from alluvium covering sandy or gravelly material, which, probably, was deposited by water issuing from melting glaciers.

Despite the porous sandy or gravelly character of the subsoil, natural drainage is poor and some tiling is necessary, in most places, to improve the soil for cultivation. In dry seasons, however, crops suffer more damage from drought, because of the low water-holding capacity of the soil. Benoit silt loam, therefore, may have both poor and excessive drainage during a single crop season.

About 65 percent of Benoit silt loam is in cultivated crops, and 35 percent is in pasture and hay land. Of the soils having restricted natural drainage, the proportion of Benoit silt loam in cultivated crops ranks second to that of Floyd silt loam and is equal to that of Floyd silty clay loam. Acre yields of corn range from 20 to 70 bushels, averaging about 35 bushels in normal years; oats yield from 25 to 60 bushels, averaging about 35 bushels; and clover and timothy hay yields from 1½ to 2 tons. The clover grown on this soil produces more seed than that grown on any other soil, and good seed crops sometimes are obtained. Where the soil is well drained, alfalfa yields from 2 to 4 tons an acre. Crop residues and manures should be plowed under periodically to keep the soil in good tilth and to maintain the supply of organic matter. Grain yields are high following legume crops, and regular cropping to clover and alfalfa in rotation with corn and oats is the best practice.

Benoit silty clay loam.—The surface soil of Benoit silty clay loam, to an average depth of 16 inches, is black silty clay loam. The material in the upper part of this soil layer, within plow depth, contains a small quantity of sand, which renders it more friable than the material in the lower part. The surface soil is underlain, to a depth of 24 inches, by dark grayish-brown calcareous silty clay loam or clay loam, which is very plastic when wet. The next lower layer is clay loam that has a large content of sand and gravel. Lime is abundant in this layer in the form of concretions, soft lime flour, and as a coating on the gravel. Below a depth of 30 inches the soil is underlain by beds of stratified highly calcareous sand and gravel.

Variations in this soil include many small areas that have a thin covering of muck on the surface, such as the area in section 25 of Lincoln Township. In other places the 4-inch surface layer may be heavy loam with heavier silty clay loam immediately below. In still other areas the subsoil both above and within the gravelly layer may contain layers of compact silty clay or clay. Examples may be found in the southeastern quarter of section 30 of Portland Township. Where Benoit silty clay loam is associated with soils of low lime content in the eastern half of the county, it may also contain small quantities of lime within the profile, but even in such areas lime is everywhere present at a depth of less than 4 feet.

Although the total area of this soil is only 6.3 square miles, it occurs in nearly all parts of the county, except that very few areas are in the westernmost tier of townships. The largest areas are east of Thornton and Swaledale on low terraces along upper Beaverdam Creek and on low terraces along a small stream south of Mason City, along Willow Creek, and along Lime Creek.

Benoit silty clay loam occupies flat or depressed surfaces on low terraces, most of the areas being slightly more depressed than those of Benoit silt loam, but a little higher than those of the Fargo soils. It has developed from heavy-textured alluvium overlying outwash gravel deposits.

Benoit silty clay loam has poor natural drainage, and few of its areas can be cropped without tiling. As a rule, natural drainage is poorer than that of Benoit silt loam. The porous gravelly layers occasionally carry seepage waters, which rise to the surface. During the longer dry periods in summer, baking and cracking of the soil results in a poor physical condition and increases the damage to crops by drought. The Fargo soils, lacking the porous gravelly subsoil, are preferred to the Benoit soils.

About 35 percent of Benoit silty clay loam is in cultivated crops, and 65 percent is in pasture and wild-hay grasses. Permanent grasses maintain a thick firm sod, except in seepy and mucky spots, and remain green about as long in the summer as grasses on the Webster and Clyde soils. Under cultivation this soil is handled in the same manner as Benoit silt loam.

Benoit loam.—The surface layer of Benoit loam is very dark grayish-brown loam 10 inches thick. The color is not so nearly black as that of the heavier Benoit soils. This layer is underlain, to a depth of 18 inches, by dark grayish-brown heavy loam slightly tinged with gray. Below this, and continuing to a depth of 26 inches, is dark grayish-brown heavy loam or clay loam, which is distinctly gray, mottled with rust brown, light gray, and yellow. This layer contains coarser sand than the layers above and also more gravel. Below a depth of 36 inches, the soil is underlain by loose stratified sand and gravel, which contains lime in the form of thin coatings on pebbles and as small concretions. The soil above the gravel contains little or no lime. The surface soil in most places is slightly acid but is nowhere strongly acid and in many places is neutral.

Benoit loam differs from O'Neill loam mainly in having a gray or mottled layer just above the gravel substratum, as a result of development under poorly drained or waterlogged conditions.

In a few areas, such as that in section 34 of Dougherty Township on the foot slope of a sand ridge, the soil is fine sandy loam that is very loose when dry. In this area the subsoil is sandy and free of gravel. In section 36 of Mount Vernon Township, the subsoil above the gravel is better oxidized than in the typical soil, and the soil closely approaches O'Neill loam. The profile of Benoit loam in section 17 of Falls Township closely resembles that of the Waukesha soils in texture.

Benoit loam occupies very small scattered areas on the terraces of Beaverdam, Calmus, and Lime Creeks. The surface of these areas may be nearly level, slightly depressed, or slightly higher than the surrounding terrain. On terraces covered mainly by the O'Neill soils, Benoit loam occupies depressions, but on terraces covered mainly by the heavier and poorly drained Benoit, Fargo, and Bremer soils it occupies slightly elevated flats.

The areas of Benoit loam are too small to influence agricultural use of the fields in which they occur. Where surrounded by the O'Neill soils they are included in cultivated fields, but where surrounded by heavier poorly drained terrace soils they are kept in pasture and hay land. With adequate drainage, Benoit loam is slightly more productive than the O'Neill soils. It is less retentive of moisture than the heavier Benoit soils, and in dry seasons crop yields are lower. The improvement of Benoit loam calls for the same management as is recommended for the O'Neill soils, but in some places improvement of drainage is an additional requirement.

Fargo silty clay loam.—The 15-inch surface layer of Fargo silty clay loam is black silty clay loam. It is underlain to a depth of 20 inches by black plastic clay with rust-brown iron stains and gray streaks and spots of lime. Between depths of 20 and 32 inches the soil material is mottled yellow-brown, rust-brown, and gray heavy silty clay loam, which is slightly lighter textured than the material in the layers above. Below this the colors are predominantly gray because of the increased content of lime, although there still are conspicuous mottlings of rust brown and yellow.

Except for a few areas in which the upper 10-inch layer is neutral, the soil ordinarily is alkaline because of the abundant supply of lime. In this respect Fargo silty clay loam differs from the Clyde soils in the eastern part of the county, which have a low content of lime. Fargo silty clay loam differs from the Webster soils of the upland only in that it occupies a position on terraces and former lake or pond beds and is developed from water-laid material instead of glacial till.

The areas of Fargo silty clay loam are generally uniform, although the texture ranges from silt loam to silty clay. In some poorly drained pockets the soils are thinly covered with muck. So-called alkali spots are common. A description of these salt accumulations and recommended methods for their improvement are given in a following section of this report. In places the subsoil contains thin veins of loose sand and gravel, similar in character to those that make up the thicker layers in the Benoit soils. Such an area is in section 16 of Lake Township.

Most of the areas are small, the largest being in the southern parts of Lake and Grant Townships.

The land is flat or somewhat depressed, and the natural drainage is deficient. Although Fargo silty clay loam may be more poorly drained than the Webster soils in the upland, improvement in drainage is generally easier, because the Fargo soils ordinarily are nearer to adequate outlets for tile.

The soil occupies back edges of terraces and beds of former lakes and ponds in the western half of the county, where it is developed from heavy calcareous alluvium of terraces or lacustrine materials deposited in lake or pond beds within the Wisconsin till plain.

A little less than half of this land is cultivated, and the rest is used for pasture and hay land. The small proportion of the total area of this very productive soil is used for crops, because of the fact that much of it occurs in small areas adjacent to beds of peat or other soils that are particularly adapted to pasture or hay meadows. A large area in Lake Township is inadequately drained, and about one-third of it is in pasture and hay land. The improved acreage in crops is very productive, but the soil has the same disadvantages mentioned for Webster silty clay loam. Equally high or better yields than those given for the Webster soils are obtained on well-drained areas.

Fargo silt loam.—Fargo silt loam differs from Fargo silty clay loam mainly in having a silt loam texture to a depth of 10 inches. Below that depth, the soil material has the same general appearance and is equally heavy in texture as Fargo silty clay loam. Fargo silt loam occupies the same general position on those parts of terraces farthest from streams and in former lake beds. This soil has been developed from calcareous alluvium under poor drainage, with a heavy grass vegetation.

Where areas of Fargo silt loam adjoin those of Fargo silty clay loam, they are slightly higher than the heavier soil and are better drained. In many places, this advantage in drainage is offset by numerous salty fringes, which occur on these slight knolls, such as the areas in section 7 of Lincoln Township. Where free of salts, Fargo silt loam is more easily maintained in good physical condition than is the heavier silty clay loam, partly because surface drainage is better and partly because of the difference in texture.

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This soil is not important agriculturally, owing to its small extent. A little less than half of it is in cultivated crops, and the rest is in pasture and hay land. Because of the small acreage of this soil, the use of the land is determined largely by the more extensive surrounding soils. With adequate drainage and correction of the salty condition, Fargo silt loam is very productive. Crop yields average about the same as on the Webster soils, and the same methods of soil management are recommended as for those soils.

Bremer silt loam.—The surface soil of typical Bremer silt loam is black heavy silt loam about 14 inches thick. The furrow slice is mellow under optimum moisture conditions but is very sticky when wet. The surface layer is underlain by very dark grayish-brown silty clay loam. Between depths of 20 and 32 inches is dark grayish-brown plastic silty clay with rust-brown stains and stains of black organic matter. Below a depth of 32 inches the material is silty clay loam, which is less plastic than the material above and more highly mottled with rust brown, yellow, and black. With increasing depth the poorly oxidized heavy alluvium contains larger quantities of sand, either in the forms of veins or mixed through the heavy soil. No boulders are present in the soil or on the surface. The soil contains no calcium carbonate and is generally leached free of carbonates to a depth of about 3 feet. In a few places the alluvium may contain some lime concretions at a depth of 4 to 5 feet. This soil differs from the Fargo soils in its lower lime content, and it differs from the Clyde soils in that it occurs on terraces rather than on the till plains.

Areas mapped as Bremer silt loam show a number of variations in profile. About one-third of the total acreage is marked by a heavier texture, in many places approaching a silty clay loam. This variation generally occurs in the areas with poorest drainage, such as those in section 28 of Portland Township and in section 9 of Falls Township. In Lincoln, Lime Creek, and Falls Townships, about one-half of the areas of this soil have a heavy silt loam or silty clay loam surface soil. In one area, in section 9 of Lime Creek Township, the subsoil is tight shaly clay. Limestone bedrock forms a deep substratum in such areas as those in section 1 of Owen Township and section 1 of Lime Creek Township. Gravel substrata occur in places at slight depths, but the gravel itself in most places is water bearing and produces little improvement in drainage conditions. Such areas occur in sections 17 and 21 of Dougherty Township.

Bremer silt loam occupies flat or slightly depressed sites on stream terraces, generally near the uplands and back of better drained areas near the streams. The poor drainage is due largely to surface run-off or seepage water from higher land. Where these waters are not diverted, the land is too wet for growing cultivated crops and is kept in hay meadow and pasture. In a few places the seepage waters are derived from limestone, as in one area in section 25 of Owen Township.

Bremer silt loam has developed from heavy-textured alluvium under conditions of poor drainage and with a luxuriant vegetation consisting of prairie grasses on the better drained areas and coarse sloughgrasses on poorly drained areas. About 60 percent of the land is used for cultivated crops and 40 percent for pasture and hay grasses. Areas too poorly drained for cultivation have a high value for pasture, and the general practice is to keep this soil in pasture where it is not needed for corn. Adequately drained areas are used for crops, particularly for corn, but yields of small grains often are decreased by the rank growth of straw and consequent lodging. Red clover does well but sometimes is damaged by heaving of the soil and winter-killing. The systems of cropping and soil management now in use are similar to those practiced on Floyd silt loam.

Millsdale silty clay loam.—The surface soil of Millsdale silty clay loam averages 13 inches in thickness and consists of black silty clay loam, which is sticky when wet and moderately friable when dry. Below the surface soil is brown fine sandy loam mottled with black stains, due to infiltrations of organic matter, and rust-brown stains due to iron. Between depths of 17 and 24 inches the dark slate-colored heavy silty clay is sticky when wet but somewhat mellow and flaky when moist. The next lower layer continues to a depth of 34 inches. It is rust-brown, yellow, and gray mottled fine sandy clay, in which are embedded fragments of partly decomposed limestone. This material overlies hard limestone bedrock. The reaction of the surface soil is slightly acid in places but more commonly is either neutral or alkaline.

Millsdale silty clay loam, as it commonly occurs, is marked by such essential features as a black heavy surface soil, a high content of organic matter, poor drainage, and underlying limestone bedrock at slight depths. In about one-eighth of the total area, the parent material consists of alluvium mixed with weathered limestone, the two materials forming a mantle ranging from 1 to 3 feet in thickness over the bedrock. This variation occurs on the flood plains of Lime Creek and Shell Rock River, in Lime Creek, Portland, and Falls Townships. The thickness of the soil above bedrock does not vary greatly on the terraces above the flood plain levels, but the surface soil shows some variation in texture, with a range from loam to silty clay loam. In a few of the better drained areas the surface soil is mellow sandy loam and the lower horizons are not so heavy as in the typical soil. Such areas occur in section 15 of Lincoln Township and section 31 of Lime Creek Township, but altogether they comprise less than 2 percent of the total area of this soil.

In seepy poorly drained spots the soil is mucky and spongy. In a few places the underlying material is a brittle flaky shale rather than decomposed limestone. Areas of this kind occur beside the open clay pits in section 32 of Lime Creek Township and in section 2 of Portland Township.

Millsdale silty clay loam lies adjacent to the main stream valleys in the eastern half of the county, in positions ranging from flat plains to uplands, where shelves of limestone bedrock are present near the surface. The common position of Millsdale silty clay loam on the uplands is in the drainageway depressions bordered by soils with limestone substrata. On stream terraces the soil occurs in positions farthest from the stream and in very few places covers the entire terrace. On flood plains it either occupies bottoms away from the streams or covers the entire bottom. The surface of this soil is flat or very slightly sloping. In section 3 of Owen Township a slightly depressed area is on an upland plain occupied mainly by Dodgeville silt loam. In sections 1 and 12 of Owen Township, areas on seepy slopes, most of which have a thin surface covering of spongy muck, occur between high and low ledges of bedrock.

Millsdale silty clay loam has developed from the weathered products of shales and limestones, which have been covered by a thin layer of alluvium or glacial drift.

About 80 percent of this soil is in pasture and hay land, and 20 percent is in cultivated crops. The pastures on the flood-plain areas are subject to more damage from overflow than are the flood plains covered by Wabash and Lamoure soils. They afford excellent grazing, however, and the greater part of this land should be kept in pasture. Those areas with a soil 3 or more feet thick and with better drainage are highly productive, if dry periods do not occur and cause damage to crops during the growing season. Crop yields are decreased by drought to a greater extent on Millsdale silty clay loam than on Benoit silty clay loam. Maintenance of optimum conditions of moisture in Millsdale silty clay loam is difficult in extremely dry or wet seasons. Plowing under manure and crop residues periodically is necessary, otherwise this soil soon will develop a poor physical condition. Drainage can be improved by diverting surface or seepage waters that flow over the areas from surrounding lands.

Millsdale loam.—The 6-inch surface soil of Millsdale loam is very dark grayish-brown mellow loam. Below this, and continuing to a depth of 20 inches, is very dark grayish-brown loam, which is slightly heavier and more compact than the material near the surface. At a depth of 24 inches the soil is underlain by weathered limestone, which contains thin interbedded layers of decomposed material. This type of limestone is locally called shell rock, and that name is given to the river flowing through the northeastern corner of the county. Millsdale loam is formed from parent material similar to that of Millsdale silty clay loam, except that it is coarser textured and has better internal drainage. The cover of native prairie grasses was thinner on Millsdale loam, resulting in a lower content of organic matter. The surface layer of Millsdale loam ranges from slightly acid to alkaline in reaction in the different areas.

One area of Millsdale loam in section 20 of Portland Township has a profile consisting of dark silt loam grading into a well-oxidized heavier silt loam subsoil, the entire profile ranging from 4 to 5 feet in thickness over the bedrock. Areas of this soil on the Shell Rock River flood plains include numerous patches of bedrock without any soil cover.

More than 70 percent of this soil is on the flood plains of Lime Creek and Shell Rock River, in Grant, Lincoln, Portland, and Falls Townships. Elsewhere the areas are very small and are scattered along the edges of terraces, which have bedrock at a slight depth beneath the surface.

Millsdale loam is agriculturally unimportant because of its small area and is cultivated only where included with a field of some other soil. Most of the soil is in pasture, and this is the best use for the greater part of it.

Lamoure silty clay loam.—Lamoure silty clay loam is the principal soil of the flood plains of the larger streams and drainageways, with the exception of Shell Rock River and Coldwater Creek in the eastern part. The 10-inch surface layer consists of black mellow silt loam with a high content of organic matter. This is underlain by black silty clay loam or silty clay, which is somewhat heavier than the material in the surface layer. Below a depth of 24 inches the material consists of very dark grayish-brown silty clay with rust-brown iron stains and gray mottlings of lime. Everywhere the subsoil is calcareous, and in some places the entire profile is calcareous.

Most areas of Lamoure silty clay loam are subject to overflow at frequent intervals, and for that reason the greater part is not cropped. The soil is highly prized for pasture and ordinarily can be used to best advantage for this purpose. A few areas not subject to frequent overflow are better drained and can be cultivated, after underdrainage has been improved. Most farmers prefer to use this soil for pasture rather than to tile it for cultivation. Under cultivation Lamoure silty clay loam calls for the same management and cropping practices as are recommended for Webster silty clay loam.

Lamoure silt loam.—Lamoure silt loam occupies comparatively small bodies along the stream bottoms in several parts of the county but covers only a small total area. It differs from Lamoure silty clay loam in having a higher content of silt in the surface soil and better drainage throughout. It occupies higher positions than does the silty clay loam, but only a small part of it is above the limit of overflow by the streams. Much of this soil resembles Fargo silty clay loam in many ways but differs from that soil in occupying a lower position near the streams.

The comparatively small part of Lamoure silt loam that lies above the frequently flooded plains can be cultivated without ditching or tiling, and a large proportion of such land is devoted to cultivated crops. Pastures on this soil are better than on other soils of the bottom lands, as the hardwood trees form a scattered stand, and their shade is not dense enough to prevent the growth of grasses.

Wabash silt loam.—The surface soil of Wabash silt loam is black mellow silt loam to an average depth of about 14 inches. The silt loam becomes heavier in texture with increasing depth, and below a depth of 26 inches it is underlain by very dark grayish-brown silty clay loam with rust-brown iron stains and some gray mottlings. The soil in few places contains lime within the upper 3 feet, and it is generally neutral or slightly acid to a depth of 2 feet. Wabash silt loam differs from the Lamoure soils principally in a lower content of lime.

Wabash silt loam occurs on the bottom lands along the lower courses of the main streams in the eastern half of the county. Natural drainage is fairly good on the comparatively few areas that are not subject to overflow, and such areas produce good crops without artificial drainage. The surface soil in poorly drained areas is heavier silt loam, in many places approaching silty clay loam. The principal areas of this kind occur in abandoned stream channels or in the lower parts of the bottoms some distance from the present channel. These areas are not suitable for cropping unless artificially drained, and for that reason they are used mainly for pasture.

Nearly one-half of Wabash silt loam is in woodland pasture, about one-third is in open pasture, and the rest is used for cultivated crops.

Under cultivation this soil requires the same management that is recommended for Floyd silt loam, but Wabash silt loam can be worked under a slightly wider range of moisture conditions. Small grains produce a growth of straw similar to that on the Floyd soils, but they mature a little earlier. Corn yields about the same on the soils of the two series, and legume hay yields somewhat better on Wabash silt loam, as the damage from winter-killing is less than on the Floyd soils.

Wabash loam.—The surface soil of Wabash loam is black mellow loam about 10 inches thick, below which the soil material to a depth of 26 inches is black friable heavy loam. Below this is black heavy silt loam or silty clay loam with rust-brown iron stains and gray mottlings. The soil contains no lime above a depth of 4 feet and in most places is acid to a depth of 2 feet.

Wabash loam does not have distinct and sharply defined layers but grades from dark-colored loam into materials that become slightly lighter in color and heavier in texture with increasing depth. In places thin layers of sandy alluvium are present in the subsoil, but these are not so thick as the layers of sandy alluvial material of the Cass soils. On some stream banks overflow deposits of sand coat the surface. All the layers in Wabash loam are more friable than those in Wabash silt loam. In some places on the flood plains of Lime Creek and Shell Rock River the substratum is limestone.

Wabash loam occurs in the flood plains of the main streams in the eastern half of the county. Areas commonly lie immediately adjacent to the stream channel, whereas areas of Wabash silt loam lie farther away from the stream, as in section 26 of Portland Township.

If Wabash loam contains no sandy layers within the profile and is not subject to frequent overflow, it is nearly as desirable for cropping as Wabash silt loam. Crops may suffer from a lack of water during dry periods in summer, and then they do not yield so well as those on the silt loam. Less than one-third of Wabash loam is in cultivated crops, and the rest provides excellent pasture.

Cass loam.—The surface soil of Cass loam is black friable loam about 10 inches thick, which, when dry, is mellow and friable. Below the surface layer and continuing to a depth of 22 inches is black heavy loam, which is underlain, to a depth of 32 inches, by dark grayish-brown heavy loam with faint stainings of yellowish brown. The sand content increases with depth, and below a depth of 32 inches the material is loose coarse sand with a low water-holding capacity.

Cass loam occurs only along the channel of Beaverdam Creek in Mount Vernon and Geneseo Townships and is almost entirely in woodland pasture.

This is not considered a suitable soil for growing cultivated crops, and unless it forms part of a field of more desirable soil it is not used for this purpose. The better areas, where the layers of fine material are thicker, should return somewhat higher crop yields than those obtained on O'Neill loam. Methods of improvement recommended for O'Neill loam apply to this soil as well.

EXCESSIVELY DRAINED SOILS

Within this group are placed those soils that have a low water-holding capacity, owing to the porous character of the lower layers of the profile. Several large unbroken areas of these soils occur in the county, and altogether they cover 9.1 percent of the land surface.

The group includes six soil types belonging to three soil series. The loam and silt loam of the O'Neill series occupy outwash and stream terraces. Their surface layers have good water-holding capacity, but the porous gravel beneath retains very little water. The loamy fine sand, sandy loam, and loam of the Dickinson series and the loam of the Pierce series, on sandy and gravelly materials of the glaciated rolling upland, are mapped. Pierce loam and Dickinson loam occupy rounded knolls and ridges from which some water is lost by run-off as well as by percolation through the porous subsoils. When dry, Dickinson loamy fine sand is subject to some wind erosion.

O'Neill loam.—The 7-inch surface soil of O'Neill loam consists of dark grayish-brown loam with a considerable content of coarse sand. It is underlain, to a depth of 15 inches, by dark grayish-brown loam with slightly heavier texture. Below this, and continuing to a depth of 21 inches, is dark-brown heavy loam, which has a gritty feel, due to its content of coarse sand. This material becomes more sandy below a depth of 21 inches and gives way to yellowish-brown coarse sandy loam. Below a depth of 32 inches the soil is underlain by loose stratified sand and gravel. No limestone is present in the typical soil, and the soil above the gravel layer has a strong to medium acid reaction. In much of the area of O'Neill loam, as mapped in this county, a small proportion of the underlying gravel is composed of limestone, and in places the gravel and boulders in the upper part of the soil are coated with lime. This calcareous gravel generally lies below a depth of 3 feet, but in a few places it lies within 30 inches of the surface. The layers of finer material above the gravel, however, are slightly to medium acid.

Minor variations in the soil occur in the different areas mapped, but they all have a low water-holding capacity. In a few places O'Neill loam has a heavier textured layer just above the porous gravel, as commonly occurs in the profile of Benoit loam. An area of this kind occurs in sections 16 and 17 of Portland Township. Another variation, in which fine sandy loam overlies material a little heavier in texture, occurs in sections 1 and 12 of Mason Township. Areas of O'Neill loam that are less calcareous in the lower part of the profile occur in several townships, but the largest are on terraces north of Lime Creek in Portland Township. The areas underlain by calcareous gravel are most extensive along Lime and Willow Creeks, along the upper branches of Beaverdam Creek, and east of Swaledale.

Most, if not all, of O'Neill loam retains but small amounts of water, and crops may suffer in dry seasons. Some areas that have a high water table or carry seepage waters within the reach of plant roots are excellent farm land; for example, those in the vicinity of Swaledale.

About three-fourths of the acreage of O'Neill loam is in cultivated crops, and the rest is in pasture. In very favorable seasons this soil produces crops equal to those on the better upland soils. Crops on the deeper and better areas of this soil are injured only in periods of prolonged drought, whereas those on the typical soil show injury after a short period of dry weather. Plowing under barnyard manure, crop residues, and green-manure crops may help to increase the capacity of the soil to store water. As the soil is generally acid, liming ordinarily increases the yields of legumes and succeeding crops. Corn and small grains cannot be grown so often on this soil as on the heavier soils, and a still larger proportion of the land should be kept in legume-hay crops in order to maintain productivity.

O'Neill silt loam.—The surface soil of O'Neill silt loam is very dark grayish-brown mellow silt loam with a considerable content of fine sand. It is thicker and has a higher content of organic matter than that of O'Neill loam. Depth to gravel in O'Neill silt loam is slightly greater than it is in O'Neill loam, and the soil can store larger quantities of moisture above the gravel layer. It is only in exceptionally favorable seasons, however, that crops do not show some damage from drought.

The largest areas of O'Neill silt loam occur along Lime Creek in Mason and Portland Townships. The areas in sections 1 and 2 of Mason Township are heavier in texture, approaching a clay loam. The soil material over the porous gravel is deeper than typical in an area in section 12 of Portland Township. On low terraces the upper part of the subsoil is slightly mottled, approaching the color found in Benoit silt loam, as in areas in sections 18 and 20 of Owen Township and section 1 of Geneseo Township. In places, limestone underlies the gravel at a depth of several feet, as in section 11 of Mason Township.

Several small areas differ from the typical soil in having gravel and sand substrata composed in part of limestone. The depth to the calcareous material ranges from 40 to 80 inches. O'Neill silt loam differs from Benoit silt loam in occupying higher and better drained terraces, which allow better aeration and oxidation. All areas of this variation are small and form only parts of the fields in which they occur.

Typical O'Neill silt loam occurs in the eastern part of the county with about one-half of its acreage in Falls, Mason, and Portland Townships. The areas underlain by limestone are mainly in Grant, Lime Creek, and Lake Townships. The total area of this soil is 36.6 square miles.

About three-fourths of O'Neill silt loam is in cultivated crops, and the rest is used for pasture. Crop yields average slightly higher than on O'Neill loam. O'Neill silt loam requires the same management as O'Neill loam, with special emphasis on practices looking to the maintenance of a supply of organic matter. With liming, just as good stands of alfalfa or clover can be obtained as on O'Neill loam. Without liming, the O'Neill soils cannot be expected to produce legumes as well as soils with a higher supply of lime.

Dickinson loam.—The surface soil of Dickinson loam is very dark grayish-brown mellow loam having an average thickness of about 11 inches. Below this, and continuing to a depth of 20 inches, is yellowish-brown fine sandy clay loam, which is slightly sticky when wet. Between depths of 20 and 40 inches the soil material is yellowish-brown loose sand containing pebbles and being slightly stained with iron. Below this, and continuing to a depth of several feet, is light yellowish-brown loose sand, which contains more gravel and more rust-brown iron stains than the layer above. It may contain very thin veins or spots of cemented sand in places, but these spots do not greatly improve the water-holding capacity.

Some boulders are present on the surface and throughout the soil, and a few lime-coated pebbles appear in places at a depth of 5 or 6 feet. In all areas in the eastern half of the county in the Iowan till area, the material is medium to strongly acid at all depths, but some of the areas in the western half of the county in the Wisconsin till area contain lime in the sandy subsoil at a depth of 4 feet or less. Dickinson loam differs from Pierce loam principally in that it has been developed from sandy rather than from gravelly materials.

In section 36 of Falls Township the sandy subsoil is slightly red and undoubtedly contains an admixture of material weathered from sandstone. Other areas of Dickinson loam are associated with the Dodgeville soils, as in section 27 of Falls Township. Still others are associated with Lindley loam, as in section 6 of Falls Township and section 36 of Mason Township. A few areas of Floyd soils surround slightly elevated knolls covered by Dickinson loam, many of which are too small to map. These areas, when plowed, show up in marked contrast to the heavy Floyd soils, as they dry out rapidly after rains. Such areas occur in sections 24 and 25 of Geneseo Township.

Dickinson loam occupies rather prominent knolls or low ridges in till plains. This soil more often occurs on the upland bordering the main stream valleys than on the open plains more distant from streams. Losses of water from areas of Dickinson loam occur both in the form of run-off and percolation, the latter, perhaps, being greater.

Dickinson loam is not extensive. Most of it is in Geneseo, Portland, and Falls Townships.

Less than two-thirds of this soil is in cultivated crops, a very small area is in forest or woodland pasture along stream bluffs, and the rest is in open pasture. Most of the areas are so small that they are farmed with surrounding soils, chiefly of the Carrington series. The same crops are produced and the same farm problems are experienced as on O'Neill loam.

Dickinson sandy loam.—This soil is similar to Dickinson loam except that it has a sandy loam texture in the surface soil. When dry the soil materials blow or drift to some extent, but crop damage from this cause is not so severe as on Dickinson loamy fine sand. The typical profile of Dickinson sandy loam from the surface downward consists of a layer of dark grayish-brown fine sandy loam, approximately 1 foot thick, underlain by a 1-foot layer of heavier fine sandy loam or loam, and this, in turn, is underlain by a 1-foot layer of coarser loam, about as heavy as that above. Below a depth of 3 feet these sandy loam areas are underlain by porous loose gravelly sand. This soil is acid throughout where it occurs in the Iowan till plain, but a few small areas in the Wisconsin till plain in the western part of the county are underlain by calcareous material at a depth of several feet.

The areas of Dickinson sandy loam are small and scattered. The larger ones in Pleasant Valley Township are less droughty than the areas elsewhere, and they include small patches of Clarion loam and

Dodgeville loam. In section 15 of Owen Township the soil occurs on knolls surrounded by Floyd soils. In section 31 of Portland Township this soil is associated with Dodgeville loam.

Added to its low capacity to hold moisture, the tendency to drift further reduces the value of the soil. It must be more carefully managed than Dickinson loam if the crops grown are to be at all satisfactory. The practices recommended for Dickinson loam apply to this soil, but rotations should be longer, with a smaller proportion of cultivated crops.

Dickinson loamy fine sand.—Dickinson loamy fine sand consists of dark grayish-brown incoherent loamy fine sand to an average depth of about 10 inches. Below this, and continuing to a depth of 22 inches, is very dark brown fine sandy loam, which is more coherent than the material in the surface layer. Dark organic stains penetrate this layer but thin out with depth. Between depths of 22 and 28 inches the material is yellowish-brown heavy fine sandy loam, which is slightly sticky when wet. It grades into pale yellowish-brown porous sand. The reaction is strongly acid throughout.

The most prominent area of Dickinson loamy fine sand occupies a narrow ridge, locally known as Dougherty sand ridge, which forms a divide between Beaverdam Creek and Coldwater Creek. Together with adjacent areas, which are less ridged, the soil has a total area of 1.8 square miles. All this soil occurs in Dougherty, Owen, and Geneseo Townships. One of the results of wind erosion on the Dickinson soils is evident in the farm wood lots, which have acted as wind dams and in which wind-blown deposits ranging from 8 to 16 inches in thickness may occur. About 38 percent of this soil is cropped, 6 percent is in wood lots and oak thickets, and the rest furnishes scanty pasture. The general farm crops are grown, but, in general, areas of this soil detract from the value of a farm. Stands of alfalfa and sweetclover are hard to obtain because of the low supply of moisture, but pasture and hay grasses can be more easily grown. Green manuring is especially important for the improvement of the soil. Melons are adapted to this soil, but they are grown only on a small scale.

Pierce loam.—The surface layer of Pierce loam, to a depth of 4 inches, is dark-brown loam containing some coarse sand. Below this is dark-brown firmer and heavier loam, which continues to a depth of 11 inches. The next lower layer is moderately dark brown heavy sandy loam containing a small quantity of gravel. Below a depth of 22 inches the soil is underlain by brown loose sandy loam containing large quantities of glacial gravel and a few boulders. With depth, porous gravelly and sandy beds are mixed and cross-bedded. The gravelly beds contain numerous limestone cobblestones, many of which are thickly coated with secondary lime.

Pierce loam is a soil of small extent. It occupies rather prominent knolls or narrow ridge crests, associated mainly with Clarion fine sandy loam and the rolling phase of Clarion loam. Very small areas are scattered over the main morainic surface of the Wisconsin till area in the western part of the county, principally in Grant Township. The largest body is in section 4 of Grant Township. The bodies in sections 5 and 6 have large quantities of boulders scattered over the surface, which are indicated on the soil map by stone symbols.

Gravel lies at various depths, and the areas underlain by gravel are very spotted and difficult to define. Areas of Clarion loam, too small to indicate on the soil map, are included with areas mapped as Pierce loam, and vice versa, numerous small areas of Pierce loam are too small to separate from areas of Clarion loam.

Less than one-fourth of Pierce loam is in cultivated crops. The cultivated patches commonly are included in fields of Clarion loam, where it is impracticable to farm around them. These spots plainly show damage from drought during the dry summer periods. Corn fires badly on this soil, and oats ripen earlier on shorter straw. The land furnishes but poor pasture. A profitable use could be made of some of the areas as gravel pits to supply material for surfacing roads. The gravel deposits are not large enough to justify commercial development as on the gravel deposits of the outwash terraces near Clear Lake and Mason City.

ORGANIC SOILS

The organic soils, including peat and muck, comprise a total area of 20.5 square miles, or 3.7 percent of the county. A considerable part of their acreage has been tapped by drainage tile or ditches and is partly improved, but only a comparatively small proportion has been adequately drained and can be farmed with the higher mineral soils. The organic soils have developed in former lake and pond beds, in which partly decomposed plant material has accumulated in very thick beds. Peat is less decomposed than muck and contains less mineral soil material. These organic soils have developed under swampy conditions under a rank native vegetation of water-loving grasses and sedges. In this county all the organic soils are high in lime and are alkaline in reaction.

Peat.—Peat is an accumulation of partly decayed plant remains, formed in shallow depressions, marshes, or lakes, in which water-loving grasses have grown for long periods and the remains have fallen into shallow waters. In the absence of air, little decomposition has taken place, and the plant residues have, in places, formed deposits of great depth.

The surface layer of peat, generally from 8 to 12 inches thick, consists of a dark reddish-brown mass of partly decayed plant remains. Below this, and continuing to a depth ranging from 30 to 50 inches, the plant remains are less decomposed and more fibrous, and the mass is lighter reddish brown. The depth to the underlying clay is extremely variable. In the smaller areas the layer of peat generally ranges from 15 to 30 inches in thickness, below which black mucklike clay grades into drab or gray calcareous clay. In the larger areas the depth of the clay substratum is as much as 15 feet in some places.

Areas of peat differ in a number of respects, such as the proportion of mineral materials, the thickness of the organic layer, the depth to clay, the presence or absence of salts, and the conditions of drainage.

In sections 1 and 12 of Grant Township, a narrow area of peat has a 1- to 2-foot covering of black mineral soil, which was washed from the higher lands. The mineral surface soil is not firm enough to support heavy farm implements. In the narrow upper drainage basin of Calmus Creek in Lincoln Township, peat is associated with the

Benoit, Fargo, and O'Neill soils on bordering terraces. In section 34 of Dougherty Township, peat in the basin of a former pond below the sand ridge is well tiled and is in cultivation. In section 23 of Owen Township, peat on a bottom-land area of Wabash soil receives seepage water from limestone. In section 9 of Falls Township, peat occupies a dip in a terrace. In Clear Lake Township, several peat areas lie back from the lake and are separated from it only by the lake beach ridge. A former extension of Clear Lake, in section 19 of Clear Lake Township, now existing as a swamp or an intermittent shallow lake, is filled with peat. The largest undrained area in the county, lying between two terrace levels of O'Neill soil, extends in a strip about three-eighths of a mile wide and 3 miles long in sections 11 and 14 of Lincoln Township. A shrubby growth of willows and alders, together with grass, covers its trampled surface. In Union Township, several large peat areas are tapped by ditches draining into branches of Beaverdam Creek. One of the peat beds, which is drained and successfully cropped to potatoes, onions, and truck crops, is in section 19 of Lake Township.

No areas of peat in the eastern half of the county are of any agricultural importance. The largest acreages are in Grant, Clear Lake, and Union Townships.

The most successful farming on peat consists of growing potatoes, onions, celery, and truck crops. Commercial fertilizers pay good returns when used on peat land for potatoes. From 200 to 500 pounds an acre of 0-9-27[5] fertilizer applied to peat brings yields of high-grade market potatoes ranging from 250 to 400 bushels an acre. Onions do well on peat and yield as much as 300 bushels an acre. For such intensive cropping the peat must be well drained, but it is desirable to maintain the water table at a depth not lower than 5 feet, otherwise the surface layer of the peat will become too dry and loose and will blow or drift in the wind. Only a very small proportion of the peat areas is intensively cropped in this manner. Most of the peat occurs in small areas comprising only a small proportion of the various farm units, and few of these peat bogs are sufficiently drained for regular cropping. The main tile, which drains the surrounding soils, traverses most of the peat area, but this alone is in few places adequate to drain the peat land. The most common use of peat land is for pasture and wild hay with occasional cropping to corn, oats, flax, and emergency hay and forage crops. The production of grain meets with variable success. Some peat areas support only a straggling growth of grains, others produce good stalks but do not mature the grain, and still others mature fair grain yields. Differences in the productivity of peat, once good drainage has been established, may be due to one or more of several different factors (*6*).

Muck.—The acreage of muck in this county is a little more than one-half that of peat. It is widely scattered throughout the county. Grimes, Union, Mount Vernon, and Lincoln Townships have the largest acreages.

Muck occupies shallow depressions within areas of Webster, Clarion, and other soils, and in many places it is associated with the peat deposits. Many spots of muck, too small to show separately on the map, are included with the surrounding soil types. Muck, like peat, occurs

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

in sloughs or pondlike depressions that at one time were under water but now are drained.

Muck represents a more advanced stage in the decomposition of plant remains than does peat. It is a dark grayish-brown or black smooth soft mass of organic matter mixed with various quantities of mineral soil particles. The depth of the muck varies widely between 1 and 36 or more inches, but the average depth to the underlying clay or sandy clay is about 18 inches. Most of the underlying material is black silty clay, high in organic matter, which extends to a considerable depth below the muck or gives way to somewhat gray mottled clay containing glacial pebbles.

Many small areas of muck are scattered over the county. It occurs on a back terrace northwest of Wheelerwood and in section 12 of Lincoln Township. In section 25 of Clear Lake Township it lies back of the lake beach ridge, and similar areas are along the north shore of the lake; in section 33 of Portland Township it lies on the flood plain of Lime Creek between the Millsdale and Wabash soils; in section 27 of Geneseo Township it occurs in a narrow drainageway receiving seepage water from limestone bedrock in the higher land; and in section 23 of Grant Township it borders peat beds.

Small acreages of muck are cultivated along with the adjacent areas of other soils, generally of the Webster or related series. The muck areas are used more for the production of hay and corn and less for oats and other small grains, as the small grains are apt to lodge. Most farm units include only small acreages of muck that are devoted to pasture and wild hay. The maturing of grain crops is commonly uncertain on muck as it is on peat, although muck is a little better in this respect. The requirements for improving muck land for cropping are similar to those for peat.

MISCELLANEOUS LAND TYPES

Beach sand.—Several small areas of beach sand have been mapped along the margin of Clear Lake. The material consists of sand of various grades, the finer ones predominating. It has been thoroughly leached by the fluctuations of the lake level and by wave action. The greater parts of the areas are bare of vegetation, but in places coarse grasses and shrubs partly cover the surface. The land has no value for farming. A part of it is desirable for recreational purposes, and most of it is used for bathing beaches. Many areas of this land are too small to indicate on the soil map.

Quarries.—Extensive excavations have been made near Mason City for the purpose of quarrying limestone for the manufacture of cement and for other purposes. The largest are north and east of the city. The greater part of the area of the original soils, which were principally of the Dodgeville series, has been destroyed, and the land at present has no agricultural value. The deeper pits are filled with water during a part of or all the year. The most important excavations are indicated on the soil map by quarry symbols. The less extensive pits are included with the soil type in which they occur and are indicated on the map by symbol.

Some clay beds reached by stripping a thin covering of soil have been quarried and used by the clay works and cement plants at Mason City. The large quarry symbols shown on the map in section 8 of Mason Township and in section 32 of Lime Creek Township indicate open pits of this kind. The largest natural exposure of these clays, indicated on the map by rock outcrop symbols, is along the bluff south of Lime Creek in section 34 of Portland Township. These particularly heavy clays occur in a strip of land running west from section 34 of Portland Township to Cameron, thence northwest to a point between Emery and Mason City, where it tapers off. In the areas of Clyde soils in the southeast quarter of section 30 of Portland Township, in section 7 of Mason Township, and in a few other low places tight clays lie 4 feet or less below the surface, but elsewhere in this strip they are at too great a depth to detract from the agricultural value of the land. These tight clays are thinly covered or lie at a depth of several feet in scattered spots elsewhere in the county. A description of these clays and their properties suiting them for industrial uses appears in volume 14 of the Iowa Geological Survey (*2*).

The tighter, more compact, and clayey subsoils in Carrington silt loam, Carrington loam, and Floyd silty clay loam areas in the northern part of Portland Township on the upland divide between Shell Rock River and Lime Creek, and also west of Blair Creek in the northwestern part of Lime Creek Township, appear to be developed from intermixtures of these clays with the glacial drift materials.

LAND USES AND AGRICULTURAL METHODS

According to the 1930 Federal census, the total acreage in crops in 1929 in Cerro Gordo County was 247,178 acres, of which 45.4 percent was in corn, 29 percent in oats, 13.4 percent in hay crops, and the rest in minor crops including barley, wheat, rye, potatoes, sugar beets, and truck crops. Although the acreage in some crops, as shown by the 1935 Federal census, had increased, damage from drought was so severe in 1934 that the figures of that census are less representative than those of the 1930 Federal census, and for this reason the latter are used more generally in this report.

Corn is the most important crop, and land well suited to this crop is highly prized. Nearly all of the soils have at some time been cropped to corn, and in favorable seasons the yields are satisfactory. The heavy black soils produce the highest average yields and are therefore planted to corn more continuously than the other soils. The silt loam and silty clay loam types of the Webster and the Floyd series are kept almost continuously in corn, and the loam and silt loam types of the Carrington and Clarion series rank next in the production of corn.

The Federal census for 1930 reports that corn from 75.9 percent of the corn acreage was harvested for grain in 1929, yielding an average of 36.5 bushels an acre; from 10.5 percent was cut for fodder; from 7.6 percent was hogged down or grazed off; and from 6 percent was cut for silage. About 87 percent of the corn harvested for grain is fed on the farm where grown, and the income from the sale of the remainder constitutes about 35 percent of the total income from all crops marketed. It ranks second only to the income from the sale of oats.

Land is prepared for corn by plowing and then disking until a good seedbed is obtained. It is good practice to plow the heavy black loam soils in the fall in order that the furrow slice may be exposed to the action of frosts. The structure of heavier soils is improved by freezing and thawing, and this provides a good seedbed for early planting. The lighter textured soils and those on steeper slopes should be kept in stubble to prevent erosion over the winter and plowed in the spring. These soils are easy to work and can be made ready for planting by May 1. Except for silage corn, which ordinarily is drilled, all the corn is planted in checkrows so that cross cultivation can be practiced. Corn for silage is cut by the latter part of September. In 1929 about one-fourth of the farmers in this county cut corn for silage. The corn for grain is harvested about October 15. Corn picking generally is done by hand, but the number of mechanical corn pickers is increasing rapidly.

The most popular varieties of open-pollinated corn are Golden King, Minnesota 13, Reid Yellow Dent, Ioleaming, and Golden Reid of the yellow dent varieties, and Silver King and Iowa Silvermine of the white dent varieties. The popularity of improved hybrid strains, however, has increased enormously in recent years.

Of the 2,004 farms of the county in 1929, 1,551 produced oats on 71,400 acres, or an average of 46 acres a farm, with an average acre yield of 33.6 bushels. Most of the oats are fed, but the part marketed brings a larger cash income than any other grain crop sold. Oats are grown chiefly because of their suitability as a crop to follow corn and their value as a feed crop. Corn-stubble land is disked and harrowed preparatory to sowing oats, which is done during April, usually with a drill. The grain matures during July and is cut by binders and cured in stacks in the field for threshing.

The most popular oat varieties are Iogold, Richland (Iowa 105), Albion (Iowa 103), Silvermine, and Gopher. Early and medium early maturing strains are preferred to late-maturing strains.

Barley, wheat, and rye compete with oats for a place in the cropping system and are grown to a smaller extent. Velvet, Oderbrucker, and Wisconsin Pedigree 37 and 38 are the varieties of barley generally grown. The last two are preferred for malting, but only a few farmers grow this crop for market. Spring wheat is more popular than winter wheat, and the main varieties are Komar, Marquis, and Ceres. Wilt-resistant varieties of flax are used, and the principal varieties are Bison, Redwing, and Winona.

The tame hay most generally grown is a mixture of timothy and red clover. Seedings of timothy or red clover alone are less common, and alsike and mammoth clovers are seeded only occasionally. Millet, Sudan grass, rape, and sorghum are grown to small extent for hay and forage. In 1929, 321 farms reported 2,804 acres in alfalfa, averaging 8.7 acres a farm, and producing an average acre yield of 2.3 tons of hay. Alfalfa is sown alone or with a small-grain nurse crop and gives the largest yield of hay during the second and third years after seeding. Two or three cuttings a year are made, depending on the stand. On some farms, wilt may so damage the crop that it is impracticable to keep the stand more than 3 years, but ordinarily the yield will be satisfactory for 5 years or more before grasses and weeds crowd it out. The main disadvantage of fitting alfalfa into a cropping system with corn and oats is that it competes with those crops for farm labor, so that either additional labor must be provided or the acreage of grain crops must be reduced. Alfalfa in this county seldom produces seed, therefore little or no seed is harvested. The preferred varieties of alfalfa are Grimm, Dakota No. 12, Cossack, and Common.

In 1929, 645 acres of sweetclover, crimson clover, and lespedeza were cut for hay on 58 farms, and 1,401 acres of sweetclover were pastured on 92 farms. Sweetclover is a legume grown to improve the soil and is particularly beneficial for this purpose when plowed under as green manure, but on most farms only the pasture or hay stubble is plowed under. Sweetclover furnishes less desirable hay than does alfalfa, and its chief use is for pasture. Seed is harvested from small acreages.

In 1934, soybeans were produced on 13,070 acres on 1,173 farms, an average of 11.1 acres a farm. The crop is grown mainly for hay, but some seed is used as a high-grade concentrate, and lately more has been used by oil mills. At present soybeans are grown mainly as an emergency feed crop rather than as a member of a rotation. They give satisfactory yields on the more acid soils.

Low yields of alfalfa and sweetclover are due mainly to winterkilling, dry seasons following seeding, and lack of lime. Winterkilling generally is most serious on heavy soils subject to heaving. Most of the soils of the Iowan till plain in the eastern part of the county are acid, but those of the Wisconsin till plain in the western part contain an ample supply of calcium carbonate. Soils intended for leguminous crops should be tested for their need of lime, and the proper amount of agricultural lime should be applied if the soil proves to be acid.

Potatoes for home use are grown on nearly all of the farms, and on a few farms that specialize in truck crops they are grown for market. Several peat areas, which are well drained and were fertilized with 400 pounds or more an acre of 0–9–27 commercial fertilizer, have produced 250 to 400 bushels an acre of high-grade potatoes. Rotation with onions and other truck crops is practiced on most farms, to guard against diseases, to which such crops are susceptible under continuous cultivation. Sugar beets are grown under contract for the beet-sugar factories. Heavy black soils with good moisture-holding capacity are selected for this crop. Superphosphate, about 125 pounds to the acre, is the fertilizer commonly used. The common practice is to rest the land for 2 years between beet crops, in order to avoid damage from the leaf spot disease.

Permanent pastures occupy those parts of the farm that are least suited to cropping. The grass cover consists chiefly of Kentucky bluegrass, a migrant, which, with its dense sod-forming habit, has crowded out the native bluestem. Open wooded areas on the flood plains of the permanent streams support an abundant growth of grasses and are highly prized for pasture. The more densely forested slopes along the stream valleys support a sparser grass growth and furnish less desirable grazing. Most farmers use stubble fields, hay meadows, or supplemental forage crops for pasture during midsummer and fall. The pasture in the county in 1934 totaled 86,083 acres, or an average of 42 acres a farm. Of this acreage only 5.8 percent was woodland pasture, 43.7 percent was plowable pasture, and the rest was pasture unsuited for cultivation because of poor drainage or steep slope. A certain proportion of the land is too poorly drained for cropping and too boggy to withstand the tramping of pastured animals. During a part of the year the rank sloughgrass on this land is harvested for hay.

The Iowa Agricultural Experiment Station has conducted field demonstrations and experiments on the principal soil types throughout the State, and the relative effects of various fertilizer treatments under different cropping systems have been determined over periods of 15 or more years. For detailed information on the results and conclusions of these field experiments the following bulletins issued by the Iowa station at Ames should be consulted: 241, Crop Returns under Various Rotations in the Wisconsin Drift Soil Area; 243, A Study of the Organization and Management of Dairy Farms in Northeastern Iowa; 256, Types of Farming in Iowa; 268, Cropping Systems in Iowa, Past and Present; 269, Field Experiments with Fertilizers on Some Iowa Soils; 291, Soil Management on Carrington Silt Loam; 309, Soybeans in Iowa Farming; and 323, The Place of Pasture in Iowa Farming. In addition, soil survey reports by the Iowa station of all counties adjoining Cerro Gordo are available. In these reports the needs of the different soil types as indicated by laboratory, greenhouse, and field tests are given.

A leguminous hay crop is not regularly rotated with corn and oats on the average farm. Under the prevailing system of farming, legume hays are produced only on a sufficient acreage to supply the necessary feed with little or no surplus for market. Some form of rotation of crops is practiced on all farms, but not all the rotations are planned to maintain soil productivity. Systematic crop rotations will aid in maintaining productivity and will become especially important on the lighter soils.

On most farms the supplies of manure and crop residues are insufficient and should be supplemented by green manuring or applications of fertilizers. A few commercial truck growers obtain manure from the packing plant at Mason City and in addition use superphosphate and mixed commercial fertilizers. Peat land receives the heaviest applications of fertilizer, from 400 to 1,000 pounds an acre of mixed commercial fertilizer of 0–9–27 grade being used for potatoes and other truck crops. Superphosphate is used only occasionally for grain crops. Manuring and the growing of legumes are the common practices for supplying nitrogen to the soil, and no commercial nitrogen fertilizers are used. According to the 1930 Federal census, 274 farms, or 13.7 percent of the total number, reported an average expense for fertilizer of $87.11 in 1929. Many farmers apply lime to acid soils, especially when they are being prepared for seeding leguminous crops. Byproduct lime from the sugar factory at Mason City and marly limestone from a few small pits are obtained locally, and a small quantity of ground limestone is shipped.

"ALKALI SPOTS"

The term "alkali spots" is in common use to designate areas within soil types in which crops are retarded in their growth and where corn fails to mature because of an accumulation of salts. These spots commonly occur as narrow strips on the margins of local sags, formerly occupied by sloughs or ponds, or within low flat areas. In recently plowed fields these spots are gray under ordinary moisture conditions, and when the soil is dry they are nearly white. In the more salty areas a white powder forms on the surface. These spots have been formed where water flowing from higher land collects in a pond or a depression and leaves a deposit of salts when it evaporates. In most places a high content of salts is present to a depth ranging from 10 to 15 inches, but, as a rule, high concentrations of salts do not reach a depth of more than 20 inches. Below this depth the subsoil is similar to that of other poorly drained areas. Areas of peat, muck, and soils of the Fargo series include many of these spots, and they are also developed within areas of Webster, Benoit, and Lamoure soils.

An excessive amount of calcium carbonate is commonly present in these spots. Other salts are also present, but ordinarily only calcium carbonate and calcium bicarbonate occur in such abundance as to injure crops (*1*, *7*).

The improvement of drainage conditions where possible is the first method of reclaiming land containing these salts. The areas should be tiled and the soil should be loosened to as great a depth as possible so that the injurious salts will be leached down and out through the tile. In some places green manuring with sweetclover has been beneficial. Fertilization with potash is also recommended in growing crops on these spots (*6*).

PRODUCTIVITY RATINGS

In table 7 each of the soils is given a rating according to its capacity to produce the more important crops of the general region.

TABLE 7.—*Productivity ratings of soils of Cerro Gordo County, Iowa*

Soil [1]	Crop productivity index [2] for—								General productivity grade [4]	Land classification
	Corn	Oats	Barley	Clover and timothy	Soybean hay [3]	Alfalfa: With lime	Alfalfa: Without lime	Pasture [3]		
Webster silt loam, drained	105	95	95	100	100	95	90	100		
Webster loam, drained	100	95	95	100	100	95	90	100		
Webster silty clay loam, drained	100	90	90	100	95	95	90	105		
Waukesha silt loam	100	90	90	100	100	90	------	95	1	Excellent cropland.
Clarion silt loam	95	95	95	90	90	90	------	95		
Tama silt loam	90	90	85	90	90	85	------	90		
Carrington silt loam	90	90	90	85	90	85	------	90		
Floyd silt loam, drained	85	85	85	75	75	75	------	90		
Bremer silt loam, drained	85	80	80	80	80	80	30	95		
Fargo silt loam, drained	85	80	80	80	75	80	40	95		
Clarion loam	85	85	85	75	80	80	------	90		
Clyde silt loam, drained	80	80	80	75	75	75	30	100		
Floyd silty clay loam, drained	80	80	80	80	75	85	30	100	2	Good cropland.
Clyde silty clay loam, drained	80	80	80	80	75	85	50	100		
Wabash silt loam [6]	80	70	70	90	80	75	------	100		
Carrington loam	80	80	80	70	75	75	------	85		
Lamoure silt loam, drained	80	65	70	80	80	80	40	100		
Fargo silty clay loam, drained	80	75	75	80	75	80	35	95		

[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 Cerro Gordo 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.

[6] Refers only to better drained areas. Poorly drained ones used largely for pasture.

TABLE 7.—*Productivity ratings of soils of Cerro Gordo County, Iowa*—Continued

Soil	Crop productivity index for—								General productivity grade	Land classification
	Corn	Oats	Barley	Clover and timothy	Soybean hay	Alfalfa: With lime	Alfalfa: Without lime	Pasture		
Benoit silt loam, drained	75	75	75	70	75	60	30	75		
Wabash loam [6]	75	70	70	75	75	60	------	85		
Lamoure silty clay loam, drained	70	60	65	80	80	80	40	100	3	
Benoit loam, drained	75	70	70	70	70	55	25	75		
Clarion loam, rolling phase	65	65	65	60	60	70	------	80		Fair cropland.
Benoit silty clay loam, drained	65	65	65	70	65	60	30	80		
Dodgeville silt loam	65	65	65	65	65	55	------	70	4	
O'Neill silt loam	55	60	60	65	65	50	------	75		
Millsdale loam [6]	50	55	55	50	50	50	------	60		
Lindley loam	50	45	45	50	50	45	------	60	5	
O'Neill loam	50	50	50	60	60	40	------	50		
Clarion fine sandy loam	45	50	50	45	45	45	------	60		
Cass loam [6]	45	50	50	65	60	50	------	50		
Dodgeville loam	50	50	50	50	50	45	------	40		
Millsdale silty clay loam [6]	40	45	45	50	50	55	------	60		
Muck, drained	50	20	20	85	80	------	------	50		
Dickinson loam	45	45	45	40	40	55	------	40		
Webster silt loam, undrained	25	25	25	60	------	------	------	105	6	Fair to poor. cropland.
Benoit loam, undrained	30	30	30	60	------	------	------	90		
Floyd silt loam, undrained	25	25	25	50	------	------	------	100		
Webster loam, undrained	30	30	30	55	------	------	------	100		
Benoit silt loam, undrained	25	25	25	50	------	------	------	95		
Bremer silt loam, undrained	25	25	25	50	------	------	------	95		
Dickinson sandy loam	30	40	40	30	30	30	------	30	7	
Dickinson loamy fine sand	20	20	20	------	------	------	------	20		Poor cropland.
Pierce loam	15	20	20	------	------	------	------	25	8	
Peat, drained	------	------	------	65	------	------	------	40		
Fargo silt loam, undrained	------	------	------	------	------	------	------	105		
Webster silty clay loam, undrained	------	------	------	------	------	------	------	105		
Clyde silt loam, undrained	------	------	------	------	------	------	------	100		
Lamoure silt loam, undrained	------	------	------	------	------	------	------	100		
Wabash silt loam, poorly drained areas	------	------	------	------	------	------	------	100		
Benoit silty clay loam, undrained	------	------	------	------	------	------	------	95		
Floyd silty clay loam, undrained	------	------	------	------	------	------	------	90		
Fargo silty clay loam, undrained	------	------	------	------	------	------	------	90	8	Pasture land
Clyde silty clay loam, undrained	------	------	------	------	------	------	------	90		
Lamoure silty clay loam, undrained	------	------	------	------	------	------	------	90		
Wabash loam, poorly drained areas	------	------	------	------	------	------	------	100		
Millsdale loam, poorly drained areas	------	------	------	------	------	------	------	90		
Millsdale silty clay loam, poorly drained areas	------	------	------	------	------	------	------	90		
Cass loam, poorly drained areas	------	------	------	------	------	------	------	90		
Muck, undrained	------	------	------	------	------	------	------	40	9	
Peat, undrained	------	------	------	------	------	------	------	------	10	Nonagricultural land.
Beach sand	------	------	------	------	------	------	------	------	------	

[6] Refers only to better drained areas. Poorly drained ones used largely for pasture.

NOTE: Absence of an index indicates that the crop is not commonly grown, because of poor adaptation.

The productivity of each soil for each crop is compared to a standard of 100 in the columns headed "Crop productivity index." A rating of 25, for example, indicates that the soil type is one-fourth as productive for the specified crop as is a soil with a rating of 100. A standard of 100 is meant to represent the approximate average yield of the crop obtained without the use of amendments on the more extensive and better soils in the region where the crop is grown principally. Small areas of unusually productive soils or soils given amendments, such as fertilizers or irrigation, may yield larger crops than the standard, and under such conditions ratings above 100 are given.

The following tabulation sets forth the acre yields that have been established as standards of 100. These figures represent the average long-time 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
Wheat	do	25
Clover and timothy	tons	2
Alfalfa	do	4
Soybean hay	do	2½
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. Consideration must be given to all these factors in setting up productivity ratings for soil types and an attempt made to evaluate their influence. Crop yields over a long period offer the best available summation of the combined effect of the factors, and they are used as guides in the establishment of ratings wherever they are available. The data on crop yields by townships and counties, compiled by the United States census and by the State assessors, and the crop yields on the cooperative fields and plots of the Iowa Agricultural Experiment Station have been used as sources of information in establishing ratings for the soils of this county. Crop yields by townships and counties do not give information directly applicable to soil types, however, and interpretation of the data is necessary. All the ratings, therefore, are based partly on inductive estimates rather than on reported crop yields, because of the lack of definite information. Neverthless, it is believed that the ratings do provide a fairly accurate picture of the relative productivities of the soils of the county.

Current practices in Cerro Gordo County are considered to include the occasional use of legumes and the return to the land of the barnyard manure produced on the farm. Use of commercial fertilizer has not been considered a part of the current practices. Ratings are given for alfalfa when lime has been applied, as lime is needed in most places in order to obtain a stand of alfalfa.

Two ratings have been given for a number of soil types, indicating the productivity under natural conditions of poor drainage and under conditions of adequate artificial drainage. In some areas tile has been laid, but drainage still is not adequate. The productivities of such areas will be intermediate between the drained and the undrained areas of the same soil type. In some years, undrained areas of soils, such as Webster silt loam, Benoit loam, or Floyd silt loam, will produce good crops, but artificial drainage is necessary to insure greatest production over a period of years.

Poorly drained spots occur in a number of the soils in the first bottoms of the streams. Most of them are too small to be delineated on a map of the scale used, but some are shown by the use of a marsh symbol. Artificial improvement of drainage is seldom practicable in these areas, so they are used primarily for pasture.

In the column, General productivity grade, the soils are listed in the order of their general productivity under dominant current practices. The general productivity grade is based upon a weighted average[6] of the indexes for the various crops, using the average acreage and value of those crops in the county as a basis. 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 assigned; and so on. Since it is difficult to measure or to express mathematically either the exact significance of a crop in local agriculture or the importance and suitability of given soils for particular crops, the weightings were used only as guides.

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 type. Total agricultural production of a soil type depends on its extent and geographic distribution quite as much as on its actual productivity.

Economic considerations play no part in determining the productivity indexes, which are intended to refer to production of each crop or groups 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, the relative prices of farm products, and a number of factors in addition to the productivity of the soil.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of the 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 on and in it; and (5) the length of time the climatic and biologic forces have acted on the soil material.

Cerro Gordo County is in the tall-grass prairie region of the United States, from 100 to 140 miles east of the line of demarcation between the Pedocals (soils having a horizon of calcium carbonate accumu-

[6] 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, 25; clover and timothy, 10; and pasture, 20. Total average acreages of barley, alfalfa, and soybeans have been small; so separate weightings were not given to those crops in establishing the general productivity grade. The acreage of barley was combined with that of oats, and acreages of soybeans and alfalfa with that of clover and timothy.

lation), to the west, and the Pedalfers (soils without a horizon of calcium carbonate accumulation). Through centuries of moderate temperatures and rather heavy precipitation, the tall-grass vegetation has produced larger quantities of organic material, part of which has been incorporated with the soil to give it the characteristic dark-colored surface horizon. These soils are known as Prairie soils. Only in the few areas covered by forests along the streams does the soil lack the dark color characteristic of the Prairie soils. In the latter areas forests were able to gain a foothold against the grasses, and the soils resemble those of the Gray-Brown Podzolic soils of the zone farther east.

The native prairie grasses were sod-forming and mainly bluestem grasses, the chief species being bluejoint turkeyfoot (*Andropogon furcatus*). Practically none of the virgin prairie remains, and on areas least disturbed by cultivation along roads and railroads the hardier of the migrant grasses, such as Kentucky bluegrass (*Poa pratensis*) and junegrass (*Koeleria cristata*), are thickly mixed with the remnant of the native grasses. On poorly drained sloughs or lowland areas the native growth consists of coarse sloughgrasses.

The parent materials from which the soils have been formed include two principal groups—the Iowan drift in the eastern half of the county and the somewhat morainic drift of the Wisconsin glaciation in the western part. The Wisconsin drift has a high content of lime and occupies a plain with poor natural drainage. The soils formed on this plain, therefore, have been leached free of calcium carbonate to a depth of only 3 feet or less, and the subsoils are rich in calcium carbonate residual from the parent drift. The older Iowan drift occupies a region with slightly better natural drainage, and it has been leached for a longer time than the Wisconsin drift. In general, the soils formed on this drift are leached free of calcium carbonate to a depth of 5 feet or more. A difference in lime content, depending on the source of material, exists in the soils developed from materials transported and deposited on the glacial terraces and alluvial flood plains of the Iowan and Wisconsin drift plains. The two glacial tills and the mixed transported material of their associated terraces and bottoms include several different kinds of soil parent material. In addition, a few soils have developed in place over limestone bedrock, and small areas of soils formed from thin aeolian deposits cover a part of the Iowan drift.

The climatic environment under which the soils have developed is distinctly continental. The mean winter temperature is 16.9° F., the mean summer temperature 68.9°, the mean annual temperature 44.5°, and the mean annual precipitation 30.83 inches. More than half of the precipitation falls during the four months, May to August, in which vegetation grows most rapidly.

The soils best representing a stage of development normal for the Prairie zone, in which Cerro Gordo County lies, are Clarion loam of the Wisconsin drift and Carrington silt loam of the Iowan drift. Following is a description of a profile typical of Carrington silt loam, as observed in the SW¼ sec. 14, T. 96 N., R. 19 W.:

1. 0 to 3 inches, dark grayish-brown mellow silt loam, thickly penetrated and matted with fine grass roots. The material shows distinct granulation, with the granules one-sixteenth of an inch in diameter, moderately firm,

and having irregular rounded edges. The soil mass is black when moist, and very dark grayish brown when dry. The dry soil mass when crushed is dark grayish brown and only slightly lighter colored than the uncrushed soil, showing that the dark coloration imparted by the organic matter has thoroughly penetrated the soil mass and its fine granular aggregates. The reaction is medium acid.

2. 3 to 13 inches, very dark grayish-brown heavy silt loam, which is mellow and friable. Granulation is almost as pronounced as in the layer above, but the granules are larger and firmer, with a slight tendency to form still larger aggregates. The dark coloration from organic matter has not permeated the soil mass and its granules quite so thoroughly as in the layer above, and the color of the crushed soil is lighter and has a slightly brown cast. The reaction is strongly acid.
3. 13 to 17 inches, a transitional layer, in which the dark coloring gives way to yellowish brown. The uncrushed soil mass is dark grayish brown. The structure particles are larger, less granular, and more resistant to crushing than those in the layers above. The texture is heavy silt loam to silty clay loam. The reaction is strongly acid.
4. 17 to 26 inches, silty clay loam, which is moderately friable when dry but moderately plastic when wet. The material shows numerous fracture lines between irregular subangular structure particles with little or no granulation. Broken faces have a dark coating of organic matter with yellowish brown on the cut particle surface. The crushed material is brown. The reaction is strongly acid.
5. 26 to 32 inches, silty clay loam containing more sand and pebbles than the layer above. The structure is massive, with fracture lines less numerous but well marked. The reaction is strongly acid.
6. 32 to 57 inches, yellowish-brown heavy silty clay stained with rust brown, yellow, and gray. The material breaks into small aggregates, averaging one-half inch in diameter, which are firm and have sharp edges. The fracture lines are irregular in direction and pattern. The reaction is medium acid.
7. 57 inches +, stiff heavy silty clay that is highly iron-stained. This material is the oxidized Iowan drift. The reaction is alkaline. The texture of this layer is more variable from place to place than that of the soil layers above. Gravelly pockets and boulders are present in places.

The principal characteristics of the above profile, particularly as regards the structure, color, and reaction, are common to the other Carrington soils, the Tama soils, the deeper phases of the Dodgeville soils on well-drained uplands, and the Waukesha soils on the well-drained terraces. Tama silt loam in this county is less gritty silt loam than Carrington silt loam, and it continues downward without appreciable change in texture to a depth of 33 inches. The Dodgeville soils in this county are not derived entirely from limestone. The soil material has been influenced either by loess or by drift. In the first instance the soil resembles the Tama soils; in the latter, it resembles the Carrington soils. The somewhat rust-colored silty clay loam, lying immediately above the bedrock, shows the influence of weathered limestone. Waukesha silt loam on the terraces is similar to Carrington silt loam, except for a less definite structure from the surface downward.

Following is a description of a profile typical of Clarion loam as observed in the NE¼ sec. 15, T. 95 N., R. 22 W.:

1. 0 to 3 inches, very dark grayish-brown friable loam, thickly matted with fine grass roots. This material has a fragile granular structure. The reaction is slightly acid.
2. 3 to 12 inches, very dark grayish-brown or black mellow loam. This is the layer of maximum darkness and granulation. The granules average one-eighth of an inch in diameter and are firm and angular. The reaction is slightly acid.

3. 12 to 19 inches, a transitional layer consisting of very dark brown heavy loam or silty clay loam, with a structure more coarsely granular than the material in the layer above. Dark-colored organic infiltrations from the overlying layers coat the cleavage faces. The reaction is medium acid.
4. 19 to 25 inches, moderately dark brown silty clay loam containing some drift sand and gravel fragments. The structure surfaces are thinly coated with dark organic stains. The material is moderately stiff and compact. The reaction is neutral.
5. 25 to 32 inches, yellowish-brown silty clay loam with a slight gray cast. The reaction is alkaline. This material is moderately stiff and compact. In structure and consistence it is transitional between the layers above and those below.
6. 32 inches +, mellow silty clay loam with a high content of lime. The color is light yellowish brown with a gray cast, stained with yellow and rust-brown iron splotches and gray or nearly white spots of finely divided and concretionary lime. The structure is massive, and pebbles embedded in this layer are more numerous than in the layers above. The reaction is alkaline. With increasing depth this unleached drift of the Wisconsin glaciation is more variegated in color, due to rusty-iron stainings and white lime nodules or concretions. Limestone fragments, gravel, and small boulders are numerous.

Clarion loam occurs on the more gently rolling parts of the Wisconsin till plain. Where the relief is more rolling, the soil is correlated as a rolling phase of Clarion loam, which is shallower and less intensely darkened in the surface layers by the presence of organic matter.

Restricted drainage in certain areas has retarded the action of some of the soil-forming processes. In contrast to the corresponding horizons of the Carrington soil, which has the normal regional profile, the surface layers of the more poorly drained soils are intensely colored and thicker, overlying horizons that are heavier textured and have a gray or mottled coloration.

Webster silty clay loam shows the characteristic profile developed under conditions of restricted drainage on the Wisconsin drift plain. Following is a description of a profile as observed in the NE¼ sec. 34, T. 94 N., R. 22 W.:

1. 0 to 4 inches, black silty clay loam, which is moderately mellow, with fragile granules, and is thickly matted with fine grass roots. The reaction is alkaline.
2. 4 to 17 inches, very dark grayish-brown or black heavy sticky silty clay loam. The irregular massive structure aggregates show little fracture, except along root channels. When somewhat dry, the material in the upper part of this layer shows a tendency toward granulation. The granules average one-eighth of an inch in diameter, are irregularly shaped, and are closely packed together in larger structure aggregates. The reaction is alkaline.
3. 17 to 24 inches, a transitional layer, which consists of sticky heavy dark grayish-brown or gray silty clay, with vertical tongues of dark organic matter from the soil layers above. The reaction is alkaline.
4. 24 to 32 inches, bluish-gray heavy sticky silty clay mottled with yellow, rust brown, and very light gray. The massive structure is slightly fractured along irregular vertical lines. The reaction is more strongly alkaline than in the layer above.
5. 32 inches +, gray silty clay loam or silty clay, highly mottled with rust brown, yellow, light gray, and black, containing more drift sand and embedded pebbles than the layers above. Soft spots and veins of concretionary lime occur in the material, and the reaction is strongly alkaline. The material has no definite structure.

The reaction of the upper two soil layers in many places is neutral instead of alkaline but nowhere is decidedly acid.

The principal characteristics of the profile described are common to the other Webster soils, the Fargo and Benoit soils of the terraces, and the Lamoure soils of the first bottoms. The Fargo soils are developed on heavy-textured highly calcareous sediments deposited by water in former ponded depressions or on stream terraces. The Benoit soils have porous stratified sandy or gravelly layers below an average depth of 30 inches from the surface. The soil layers above this are similar to the corresponding layers of the Webster soils, except that they are more leached and slightly more oxidized. The Lamoure soils are developed from fine-textured sediments of still younger age deposited on the stream flood plains, and their character is little changed as yet by the soil-forming processes.

The Floyd soils, like the Webster soils, have the profile characteristics of soils formed under restricted drainage. They are developed, however, from Iowan drift and are leached of lime to a depth of more than 4 feet. Table 8 shows the results of mechanical analyses of samples of Floyd silty clay loam, taken at different depths.

TABLE 8.—*Mechanical analyses of samples of Floyd silty clay loam in Cerro Gordo County, Iowa*

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
338907	Surface soil, 0 to 2 inches	1.0	5.3	6.6	9.8	4.5	41.8	31.0
338908	Subsurface soil, 2 to 14 inches	1.4	5.8	6.6	8.6	4.3	45.0	28.3
338909	Subsoil, 14 to 23 inches	1.5	5.0	5.1	7.3	2.8	48.9	29.4
338910	Subsoil, 23 to 31 inches	.5	3.1	3.2	5.0	4.8	57.4	26.0
338911	Subsoil, 31 to 47 inches	1.8	5.2	7.4	14.6	8.9	38.7	23.4

The Clyde soils, developed from similar parent material, differ from the Floyd soils mainly in their less oxidized and more mottled subsoils. The Bremer soils are developed from heavy-textured low-lime sediments laid down by water in former ponded areas or on stream terraces. In many places they show almost the same degree of oxidation in the upper part of the subsoil as does Floyd silt loam, although the soil-forming processes have acted upon their parent alluvium for a shorter time. The Wabash soils are formed from the still younger heavy-textured low-lime sediments deposited on the stream flood plains and have not developed a profile showing distinct soil horizons. The Millsdale soils have a substratum of limestone at a depth of 3 feet or less.

Those soils that are excessively drained, because of rapid percolation and loss of water through a porous subsoil, have been thoroughly oxidized and leached. In all places these soils are leached free of calcium carbonate as far down as the gravelly or sandy substrata, but in the soils of the uplands the gravelly substratum, in places, contains limestone pebbles, and the gravel commonly is coated with lime. In the Dickinson soils of the uplands and the O'Neill soils of the terraces, the gravel layer does not contain limestone pebbles or lime-coated gravels above a depth of 5 feet.

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The only soil with a light-colored surface soil in this county is Lindley loam, which occurs on the forested bluffs along the main streams. Following is a description of a profile typical of this soil, as observed in the SE¼ sec. 35, T. 97 N., R. 19 W.:

1. 0 to 2 inches, dark grayish-brown coherent silty loam. Very small fragile granules adhere to the roots of bunchgrasses and shrubs, which penetrate the soil. The color of the soil is lighter after the material has been crushed. The reaction is slightly acid.
2. 2 to 9 inches, gray loam, less silty than the material in the layer above. The soil is yellowish gray when crushed. A few very fragile granules of a darker gray color adhere to the fine grass roots present in the soil, and the thin platy structure is very distinct. The reaction is strongly acid.
3. 9 to 18 inches, yellowish-gray coherent silt loam. The structure masses are fragile, irregularly shaped, but larger than in the layer above. There is a tendency toward a coarsely platy structure. The reaction is medium acid.
4. 18 to 30 inches, light yellowish-brown silt loam stained with gray and rust brown. The structural aggregates range from one-fourth to one-half inch in diameter, are irregularly angular in shape, and are fragile, but they break into smaller masses and not directly into single-grain particles as do the aggregates in the layer above. The reaction is medium acid.
5. 30 to 62 inches, highly stained rust-brown and gray very tight compact fine sandy clay containing embedded drift pebbles. The structural aggregates are large, irregularly shaped, and less angular than those in the layer above, but they are firmer and very difficult to crush to a single-grain mass. The reaction is strongly acid.
6. 62 inches +, parent material of massive structure, less compact and less uniformly textured than the overlying material.

Lindley loam is a Gray-Brown Podzolic soil developed on the forested bluffs and slopes of the main stream valleys. Calcium carbonate does not occur in this soil within 3 feet of the surface.

SUMMARY

Cerro Gordo County is in the north-central part of Iowa, in the second tier of counties south of the Minnesota-Iowa State line. Mason City, the county seat, is about 140 miles south of St. Paul, 350 miles northwest of Chicago, and 120 miles north of Des Moines.

The county is part of a glaciated plain and has numerous minor local variations in relief. In general, the westernmost tier of townships, which is within the area affected by the Wisconsin glaciation, is covered by low morainic hills and ridges, with numerous intervening lakes and marshes, but the eastern three-fourths of the county is, for the most part, very gently rolling. The altitude ranges from about 1,100 to nearly 1,300 feet above sea level, with the general slope toward the southeast.

The greater part of the county is drained by the Shell Rock River, which flows in a southeasterly direction. Local drainage had not become established naturally over a large part of the surface, but artificial drainage by ditches and tile has now reached formerly undrained areas. These have been placed under cultivation and now constitute some of the most desirable farming land.

The first white settlers came into the county in 1852. The population, according to the Federal census of 1930, is 38,476, of which 31.5 percent is classed as rural, with a density of 21.4 persons a square

mile. The original settlers were mainly native-born whites from the older States. At the present time the foreign-born people comprise only 8.3 percent of the population. Mason City has a population of 23,304 and is an important railroad and industrial center.

Transportation facilities are good. Five railway systems traverse the county, and improved highways connect the principal shipping points.

The climate is typical of the Corn Belt, with its hot summers, cold winters, and an average frost-free season of 147 days.

The agriculture is centered around the production of corn, which is grown on about 45 percent of the cultivated land. A large part of the corn is fed on the farms to the beef and dairy cattle, and the greater part of the farm income is derived from the sale of livestock and livestock products. Oats and hay are produced to supplement corn and to provide roughage for the livestock.

The soils may be placed in three broad groups on the basis of natural drainage as follows: (1) Well-drained soils, (2) imperfectly and poorly drained soils, and (3) excessively drained soils. A small area is represented by organic soils and miscellaneous land types. This grouping does not indicate relative productivity, as very productive soils exist in both the first and second groups.

The first group includes 10 soil types and 1 phase of a type, which are developed on the rolling uplands and well-drained terraces and cover 46 percent of the area of the county. Soils of the Carrington and Clarion series are dark-colored soils developed on the glaciated upland. Tama silt loam occupies similar relief but is developed from loess. Lindley loam is the only light-colored soil in the county and is developed from glacial drift under a forest cover. The Dodgeville soils are shallow Prairie soils over limestone. Waukesha silt loam is a highly productive soil on the well-drained terraces.

The second group includes soils with slow natural drainage, which may permanently or occasionally require the attention of the farmer. Their total area is 41.1 percent of the area of the county. The 20 soil types of this group were formerly too wet during a part or all of the year to produce crops satisfactorily. The greater part of the areas are now drained, and good crops are produced, except in unusually wet seasons. The most extensive of these soils are the Webster soils of the flat uplands. These soils have been largely drained and now rank among the best in the State for growing corn. The Floyd and Clyde soils occupy similar positions but are less calcareous and have a somewhat lower value than the Webster soils. The other soils of this group resemble the Webster and Clyde soils in many respects, but differ mainly in conditions of drainage, lime content, and parent materials.

The excessively drained soils, which occupy 9.1 percent of the county, have a lower capacity to retain moisture, owing to the porous character of their subsoils. In many places crops on these soils suffer in dry seasons, but in years of exceptionally high rainfall they produce fair yields. The soils of the Dickinson and the Pierce series have developed from sandy or gravelly materials of the rolling upland, and the O'Neill soils from gravelly terrace material.

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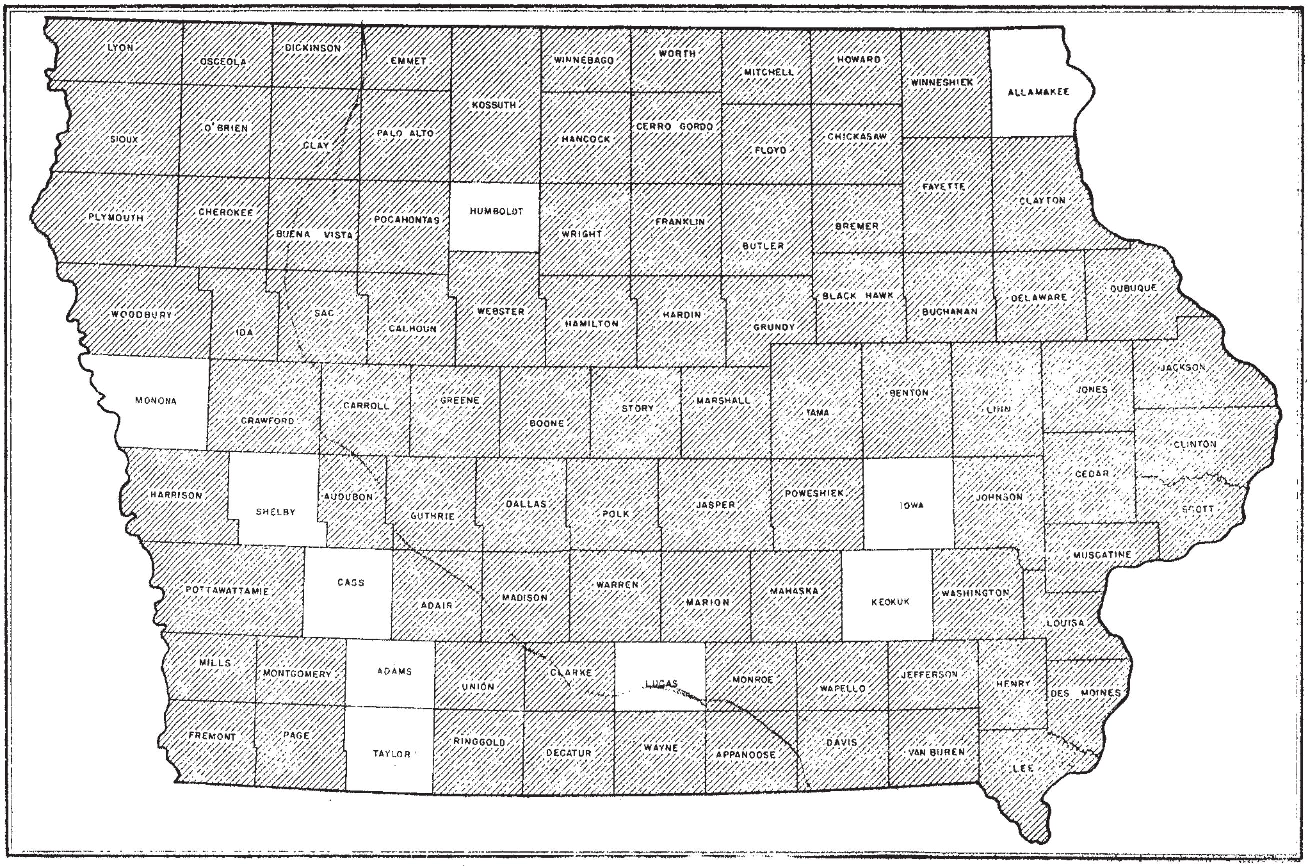

Areas surveyed in Iowa shown by shading.

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