
Soil Survey

Marion County Iowa

By
C. L. ORRBEN
Iowa Agricultural Experiment Station, in Charge
and
W. J. LEIGHTY
United States Department of Agriculture



UNITED STATES DEPARTMENT OF AGRICULTURE
In cooperation with the
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SOIL SURVEY OF MARION COUNTY, IOWA¹

By C. L. ORRBEN, Iowa Agricultural Experiment Station, in Charge, and W. J. LEIGHTY, Bureau of Chemistry and Soils, United States Department of Agriculture

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

COUNTY SURVEYED

Marion County is situated in south-central Iowa, in the third tier of counties north of the Iowa-Missouri State line (fig. 1). Its boundaries form an almost perfect square. Knoxville, the county seat, is about 35 miles southeast of Des Moines. The county contains 16 townships and comprises an area of 563 square miles, or 360,320 acres.

Marion County is part of a broad plateau into which Des Moines and Skunk Rivers, with their numerous tributaries, have cut their valleys. These rivers, which are nearly parallel to each other, cut across the northern part of the county, flowing in a southeasterly direction. Nearly all of their tributaries flow in

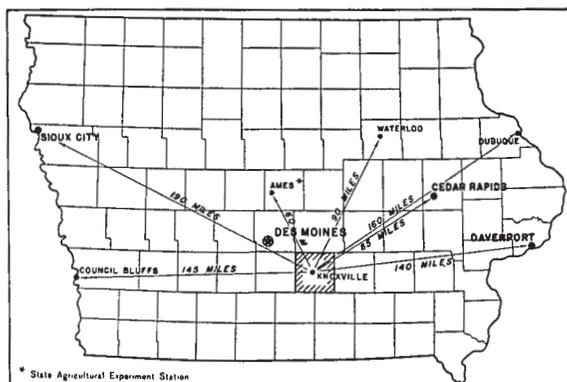


FIGURE 1.—Sketch map showing location of Marion County, Iowa.

a northeasterly direction and divide the county into several upland areas which rise to about the same general level and have similar topographic features. Remnants of the original plateau, which comprise a comparatively small part of the county, remain as winding flat-topped divides, most of them ranging from $\frac{1}{4}$ to 1 mile in width. The break from the highest divides toward the streams first takes the form of gentle slopes. At lower elevations the slopes generally become steeper, but the steeper slopes and bluffs are found only in close proximity to the streams. Characteristic surface features are developed as the streams cut through successive layers of loess, glacial drift, and alluvium.

Alluvial lands, ranging from one-eighth mile to 2 miles or more in width, are developed along the larger streams. They are most extensive along Des Moines and Skunk Rivers and Whitebreast Creek. They comprise first-bottom lands, which are adjacent to

¹ Report written by T. H. Benton, Iowa Agricultural Experiment Station.

the streams and subject to periodic overflow, and terraces, or second bottoms, most of which border the uplands and lie well above overflow. All the drainage, except in an area covering about 40 square miles in the extreme northeastern part of the county, which is carried by Skunk River, is effected by Des Moines River, which enters the county in the extreme northwestern part, flows southeastward, and leaves just south of the center of the eastern county line. Most of the streams are immature and are deepening their channels. Owing to the many steep slopes, run-off is rapid, and much soil material is carried away by the streams at every heavy rain. The fall along most streams is rapid; therefore floodwater is removed quickly and causes a minimum amount of crop damage.

Timber once covered the slopes along the main streams and their tributaries. Practically all of the large timber has been removed. Oaks, elm, ash, boxelder, hickory, and crab apple are the predominating forest trees. Much timber, which never should have been cut, has been removed from slopes along the streams, and many cleared areas on these slopes once cultivated have been abandoned to a sparse growth of brush and weeds. Considerable timber is still being cut indiscriminately for mine props, fence posts, fuel, and rough lumber. There is a scattered growth of trees, largely cottonwood, elm, walnut, butternut, willow, and basswood, along the better drained bottom lands, generally near the stream channels.

Skunk River, in the extreme northeastern part of the county, and Des Moines River, entering the northwestern part and flowing in a southeasterly direction, are the master streams. The Des Moines carries about 90 percent of the drainage waters. The principal tributary streams south of Des Moines River flow in a general northeasterly direction and those north of the river flow in a southerly and southeasterly direction. The general slope of the county is eastward. The highest recorded elevation is 1,008 feet above sea level in the southwestern part near Newbern, and the lowest (700 feet) is at the point where Des Moines River leaves the county. Other elevations are as follows: Knoxville, 925 feet; Hamilton, 906 feet; Pella, 877 feet; Donnelley, 760 feet; and Durham, 745 feet.²

Previous to 1843, when the county was opened to settlement, only a few white traders lived in this general region. Luxuriant native grasses covered the flat and gently rolling prairies, and timber grew in bands, ranging from 100 feet to a mile or more in width on many of the slopes. The majority of the early settlers came from the Eastern and Southern States. During the eighties, about 800 immigrants from the Netherlands settled in the extreme northeastern part of the county and founded the town of Pella.

The county was organized in 1845. Among the early settlers were many of German, Norwegian, Belgian, and Irish descent. Later a considerable number of people from southern Europe settled here, with the opening of the coal-mining industry. The total population, as reported in the 1930 census, was 25,727, of which 92.8 percent were of native birth. The rural population in that year was 17,704 and the urban 8,023.

² GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bull. 274, ed. 4, 1072 pp. 1906.

Knoxville, the county seat, with a population of 4,697, lies one-half mile south of the geographical center of the county. A large Federal hospital for disabled war veterans is located here. Pella, the second town in size, in the northeastern part, has 3,326 inhabitants. Central College is located here. Melcher, in the southwestern part, has 1,673 inhabitants; Pleasantville, in the northwestern part, 757; and Bussey, in the southeastern part, 546.

The county is well supplied with railroads. The Chicago, Burlington & Quincy Railroad and the Wabash Railway traverse it from the southeastern to the northwestern corners and give direct market facilities to Des Moines. The Chicago, Rock Island, & Pacific Railway lines serve the southwestern and the northeastern parts, and another branch extends eastward from Knoxville.

The county is traversed by three paved highways: United States Highway No. 163 crosses the northeastern corner in a northwest-southeast direction, a State highway extends from the northwestern corner to the southeastern corner diagonally through the center, and a State highway passes through the center in a general east-west direction. Other improved roads connect the principal towns. The dirt roads are graded and, for the most part, are well maintained.

County schools are located at intervals of approximately 2 miles, except around towns where local or consolidated schools serve the adjacent communities. Good high schools are located in the larger towns. A few rural churches are scattered over the county, and rural mail routes serve all parts. Telephone lines, well distributed through rural sections, supply many farmers with telephone service. Radios were reported in 938 farm homes according to the Iowa Yearbook of Agriculture for 1935. Approximately 90 percent of the farmers have automobiles.

The interests of the county are primarily agricultural. Most of the livestock is marketed through local buyers or shipping associations. Ottumwa, Des Moines, and Omaha are the principal livestock markets. Grain is shipped to Des Moines, Omaha, and Minneapolis. Poultry, eggs, and cream are sold locally and shipped to eastern markets.

Coal mining is a thriving and important industry. There are 78 mines in the county, employing several thousand men. The mines are located principally in the southern half. Strip and shaft mines of commercial importance are near Pershing, Durham, Flagler, and Melcher. Many slope and small shaft mines, which supply fuel for local farm homes and communities, are operated only during the fall and winter. Many of these small mines occur here and there along the larger creeks, particularly in the southwestern part of the county. The coal veins range from 3 to 14 feet in thickness with an average of 5 feet 4 inches.

CLIMATE

The climate of Marion County is healthful and typical of the Corn Belt. The distribution of rainfall and the temperature make it well suited to general farming and the growing of all crops common to this section of the State.

In table 1, compiled from the records of the United States Weather Bureau station at Knoxville, are given climatic data which are considered representative of the county as a whole.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Knoxville, Marion County, Iowa

[Elevation, 920 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1901)	Total amount for the wettest year (1935)	Snow, average depth
December.....	° F. 26.7	° F. 73	° F. -26	Inches 1.31	Inches 1.69	Inches 1.24	Inches 5.4
January.....	20.5	62	-30	1.17	.55	1.21	7.7
February.....	24.3	78	-24	1.20	.90	1.23	5.9
Winter.....	23.8	78	-30	3.77	3.14	3.68	19.0
March.....	36.6	88	-11	1.94	3.34	1.43	4.4
April.....	50.4	92	11	2.92	.69	1.88	1.7
May.....	61.3	106	25	3.87	1.41	6.24	.1
Spring.....	49.4	106	-11	8.73	5.44	8.55	6.2
June.....	70.1	105	40	4.54	4.92	12.79	0
July.....	74.6	113	46	3.82	2.66	5.03	0
August.....	72.8	114	40	4.20	.50	3.06	0
Summer.....	72.5	114	40	12.56	8.08	20.88	0
September.....	66.1	103	25	4.47	2.43	6.57	0
October.....	53.7	89	2	2.50	1.17	2.53	.4
November.....	38.8	78	-2	1.76	.27	4.86	2.0
Fall.....	52.9	103	-2	8.73	3.87	13.96	2.4
Year.....	49.7	114	-30	33.79	20.53	47.07	27.6

Of the 33.79 inches of mean annual rainfall recorded at Knoxville, 20.90 inches falls during the period May to September, inclusive, fairly evenly distributed over each month, thereby making an ideal distribution of moisture for the growing crops. Extended periods of drought are infrequent, but occasionally, as in 1934, they are serious and reduce production severely. Heavy continuous rains in the spring sometimes delay the planting of corn and the seeding of small grains. Because of the long normal growing season, corn is rarely damaged, even when it is planted late. The low rainfall in October and November favors the maturing and curing of the corn crop. Hot winds in the latter part of June sometimes damage oats and other small grains.

The average frost-free season of 166 days extends from April 25 to October 8. Frost has been recorded, however, as early as September 18 and as late as May 25.

In general, the winters are not severe. Extremely high temperatures sometimes are recorded in the summer. They are generally followed by electrical storms, sometimes accompanied by hail and strong winds. Damage to crops, however, generally is slight and local.

Southwesterly winds prevail in summer and northerly winds in winter. In winter, snowfall contributes most of the moisture, but

some rain falls in early December and late February. In open winters, with the absence of a snow cover, alfalfa, clover, and wheat are sometimes damaged by intermittent freezing and thawing of the ground. Rainfall and temperature during a normal season allow the successful growth and maturity of all crops commonly grown.

AGRICULTURAL HISTORY AND STATISTICS

The first settlers established their homes along the Des Moines River, where water, fuel, and building material were obtained easily. The slopes along the streams were heavily timbered. Wild game and fish were abundant. Hides and furs were bartered for needed household commodities. Settlements gradually extended back along the larger tributary streams and to the edge of the prairies covered with a heavy growth of native grasses which furnished grazing for livestock.

The early agriculture centered around the growing of wheat, corn, flax, oats, and potatoes, largely for local consumption. Wheat was the most important cash crop. By 1880 corn became the chief crop, with wheat ranking second in importance. Hay and oats were the other major crops.

Outcrops of coal, exposed on steep banks and slopes, were discovered along the larger creeks in the southern half of the county. Mining operations started with the removal of coal from these exposures, and many small slope mines, from which sufficient fuel was produced for the local community, were opened, but most of them have been abandoned in recent years, as the veins have been worked out. Shaft and strip mines developed as railroad facilities became available. In a number of communities, mining equaled or surpassed agriculture in importance, reaching its greatest development about 1918. Many of the miners acquired small holdings near the mines, cleared the slopes, farmed them when not working in the mines, and produced enough food and feed for their own needs. Many slopes, which were unsuited to cultivation, were ruined by gully erosion and sheet washing and were abandoned. A heavy reddish-brown clay subsoil or gray shale, on which grass will not grow, is exposed where erosion was most severe. Large strip mines are located at Durham, Pershing, and Flagler, and other large mines are near Melcher.

The present-day agriculture is based on the production of corn and the raising and feeding of hogs, cattle, and sheep. Dairying is practiced to considerable extent and furnishes an important source of revenue.

Corn has been the chief cultivated crop since the early days. About 45 percent of all land in crops was planted in corn in 1929, according to the Federal census. Corn was grown on 89,057 acres in that year, and that on 5,274 acres was used for silage or cut for fodder. Table 2 gives the acreages of the principal crops in census years since 1879.

As may be seen from table 2, corn occupied the largest acreage in 1929, with hay and oats ranking next in importance. Oats are used as a nurse crop in seeding grass for pasture or hay. A large proportion of the tame hay is made from clover alone. Hay crops yield from 1 to 2 tons an acre, depending on seasonal conditions. The acreage in alfalfa increased from 151 acres in 1909 to 4,962 acres in 1934.

TABLE 2.—*Acreage of the principal crops in Marion County, Iowa, in stated years*

Crop	1879	1889	1899	1909	1919	1929	1934 ¹
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>
Corn harvested for grain	93,527	74,633	104,641	94,003	78,311	83,783	3,087
Oats	14,631	28,165	34,688	25,682	24,259	35,584	5,264
Wheat	39,677	7,918	7,197	8,975	39,428	7,966	8,746
Barley	58	101	1,184	4,034	599	1,267	44
Rye	1,656	1,142	1,237	343	627	354	970
Soybeans						583	9,051
All hay	27,809	47,365	30,134	41,042	26,363	38,390	18,260
Timothy and clover, alone or mixed			³ 2,750	39,821	24,979	32,925	3,491
Alfalfa				151	415	4,031	4,962
Sweetclover						818	323
Small grains for hay			813	64	310	58	4,495
Legumes for hay					100	276	4,497
Other tame hay			25,479	241	316	170	⁴ 492
Wild hay			1,092	765	243	112	

¹ Year of severe drought in which acreages were reduced sharply.

² Includes sorghums for silage and fodder.

³ Clover alone.

⁴ Includes wild hay.

Wheat, an important crop in the early eighties, is now grown only in small patches. As a cash crop, however, it is still important. Barley is grown to a small extent, and all is fed to farm animals. There are small fields of buckwheat, rye, millet, flax, emmer, spelt, and Sudan grass. Rape is sown in cornfields or alone and is used as pasture for hogs. The 1935 census reports a large increase in the production of soybeans.

Forest products cut on farms for home use and sale were valued at \$52,705 in 1929. The value of farm garden vegetables, excluding potatoes and sweetpotatoes, was \$111,156; fruits and nuts, \$85,644; cereals, \$2,940,545; and hay and forage, \$599,550. Domestic animals had a value of \$4,332,879; dairy products, \$503,546; and poultry and eggs, \$1,076,731.

In 1935, 346,771 acres, or 96.2 percent of the land area of the county, were included in farms. Of this, improved land, including cropland and plowable pasture, comprised 66.4 percent, or 230,228 acres, that is, 93.1 acres a farm. The average size of farms was 140.1 acres in that year.

Very little fertilizer is used. In 1929, 191 farms expended \$13,758 for fertilizer, or \$72.03 a farm reporting. Superphosphate is used largely and is applied on land to be seeded to legumes. Some is used on cornland.

Table 3 shows the tenure of farms in 1900, 1910, 1920, 1930, and 1935, as reported by the Federal census.

TABLE 3.—*Tenure of farms in Marion County, Iowa, in stated years*

Year	Farms	Operated by—					
		Owners		Tenants		Managers	
		<i>Number</i>	<i>Number</i>	<i>Percent</i>	<i>Number</i>	<i>Percent</i>	<i>Number</i>
1900	2,914	1,816	62.3	1,077	37.0	21	0.7
1910	2,708	1,674	61.8	1,016	37.5	18	.7
1920	2,402	1,466	61.0	907	37.8	29	1.2
1930	2,413	1,352	56.0	1,051	43.6	10	.4
1935	2,476	1,277	51.6	1,184	47.8	15	.6

An increase of tenancy since 1900 is shown in the table. Most of the rentals are on a share basis, the owner receiving one-half of the corn, two-fifths of the small grain, and cash rent for the pasture. Cash rent is not popular because of the uncertainty of crops and markets. Where farm land is rented for cash it brings from \$2 to \$6 an acre, depending on the proportion of tillable land and its productivity. A few farms are rented on a stock-share basis where the tenant and landlord own all livestock, share and share alike. One-half of the seed is furnished by the landlord, and proceeds from the sale of agricultural products are divided equally. The tenant furnishes all labor and machinery under this arrangement, and the landlord keeps up repairs.

The value of farms (land and buildings) in 1930, according to the Federal census report, was \$35,194,248, or an average of \$14,585 a farm. The average acre value was \$103.53. Land values have suffered a sharp decrease from the 1930 level, and in 1935 the total value of farm lands and buildings was \$17,125,197, or an average of \$6,916 a farm and \$49.38 an acre. The severe drought and almost complete failure of the corn and oat crops in 1934 were factors in this fall in prices.

Labor was employed on 1,212 farms in 1929, at a cost of \$313,188, or an average of \$258.41 for each farm reporting. Since 1934, difficulty has been experienced in obtaining day laborers in the spring and fall.

Modern machinery is used on practically every farm. This includes cultivators, disks, harrows, plows, corn planters, mowers, and hay loaders. Corn binders are used by a few farmers who shock and feed the corn on the stalk. Corn pickers are used on a number of farms, but most of the corn is gathered by hand. Threshing is done by groups of farmers, the machine used being owned by a certain group or by private concerns.

Livestock is the chief source of income on most farms. A large proportion of the crops grown are fed to livestock, the sale of which generally brings a slightly higher return to the farmer than marketing of the grain direct. Table 4 shows the number and value of livestock in 1920, 1930, and 1935, according to the Federal census.

TABLE 4.—Number and value of livestock in Marion County, Iowa, in 1920, 1930, and 1935

Livestock	1920		1930		1935 ¹
	Number	Value	Number	Value	Number
Cattle.....	39,044	\$2,153,518	35,984	\$1,926,650	29,622
Swine.....	79,168	1,544,033	117,495	1,339,559	42,080
Sheep.....	20,801	230,097	37,354	276,753	26,126
Horses.....	14,669	1,205,287	10,287	700,616	8,088
Poultry.....	350,709	314,514	‡ 356,940	‡ 291,430	‡ 247,977

¹ Value not reported.

‡ Chickens only.

The sale of beef cattle and hogs provides most of the farm income. Although dairying is increasing in importance, it is carried on as a side line on most farms. The predominating dairy type of cattle is the Holstein-Friesian; Guernsey and Jersey also are common dairy breeds. The dairy products are sold on the local markets.

Beef cattle are, for the most part, raised on the farms where born. A number of farmers, however, buy feeders in the fall from Omaha, Kansas City, and Des Moines. Herefords and Shorthorns are the most popular feeders, with some Aberdeen Angus. Raising and feeding of sheep also is important. The rougher prairie land, cut-over areas, and timbered pastures are utilized for sheep pastures. Large numbers of western lambs are shipped in each year and fed, then sold with considerable profit.

The number of horses kept on the farms is decreasing. The number of colts raised is not adequate to keep up the supply of work animals. During the last 2 years, more colts are being raised, and the number of work animals should increase. Tractors and modern machinery make it possible for the farmers to get along with fewer horses.

Poultry is an important source of income. On nearly every farm from 100 to 200 chickens are raised, and large flocks ranging from 300 to 500 chickens are not uncommon. A large poultry-packing plant in Knoxville buys most of the poultry and poultry products.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of 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, consistency, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil³ 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 in mapping units. The three principal ones are (1) series, (2) type, and (3) phase.

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

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. Phenolphthalein solution is used to detect a strong alkaline reaction.

are given names of places or geographic features near which they were first found. Thus, Grundy, Muscatine, Tama, and Clinton are names of important soil series in this county.

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

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

Marion County lies within the area known as the Corn Belt of the United States, where corn is the principal crop and determines the type of farming. Corn, oats, and hay are the dominant crops in this county and generally are grown on more than 90 percent of the land used for cultivated crops.

As climatic conditions are nearly uniform throughout the county, they do not determine local differences in the use of the land. The character of the soils and the relief on the particular farm largely decide the type of farming practiced and the crops grown. The almost level to gently rolling lands with mellow loam and silt loam soils are adapted to general farming and to the growing of corn, small grains, and clover in regular rotations. The soils of the steeper slopes are used for the production of hay crops and for pasture. In the rougher and more broken areas only small fields are cultivated, and the rest of the land is used for pasture. Timber grows abundantly on the slopes adjacent to stream courses, but most of the land

has been cut-over. On cut-over areas, stumps, sprouts, and underbrush crowd out the grasses and limit the use of the land for grazing.

Many slopes in the rolling and hilly areas are so eroded, as a result of poor management, that the heavy tough subsoils are exposed. In some places gullies have cut into the raw subsoils after the removal of the surface soils. Many fields are abandoned, as crops cannot be produced successfully on the denuded infertile slopes. When they are abandoned and undeveloped, gullying may become serious before a cover reestablishes itself.

Corn is grown on practically every soil in the county. The dark-colored Prairie soils on the flat or almost level divides are the best soils for the production of corn, as they are mellow, easy to cultivate, highly fertile, and retentive of moisture. A few small flat or depressed areas within the almost level divides, which are not indicated on the soil map as separate types because of their small size, have a gray or almost white floury silt layer at a depth ranging from 8 to 14 inches below the surface. Corn does not produce well on these areas, but small grains are grown successfully.

The dark-colored Prairie soils on slopes cover a large part of the county, and most of the corn and small grain produced is grown on these soils. In many places fertility has been depleted, and much soil has been lost by sheet erosion on sloping areas, where not well managed. Control of soil erosion is necessary if these dark-colored slope lands are to be cultivated and their productivity preserved and maintained on a satisfactory basis.

As color indicates the properties of the soil, it may be taken, in part, as a guide to the agricultural value. On the basis of this characteristic, the soils of the county may be placed in three broad groups: (1) Dark-colored soils of the uplands and terraces, (2) light-colored soils of the uplands and terraces, and (3) soils of the bottom lands. Soils of the bottom lands are predominantly dark colored and include only a few small areas of light-colored soil.

In the following pages the soils of Marion County are described in detail, and their agricultural importance is discussed. An accompanying map shows their location and distribution, and table 5 gives their acreage and proportionate extent.

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

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Grundy silt loam.....	23, 552	6. 5	Putnam silt loam.....	512	0. 1
Muscatine silt loam.....	16, 900	4. 7	Weller silt loam.....	3, 840	1. 1
Muscatine silt loam, slope phase.....	23, 552	6. 5	Lindley silt loam.....	23, 744	6. 6
Tama silt loam.....	76, 928	21. 4	Jackson silt loam.....	640	. 2
Tama fine sandy loam.....	1, 088	. 3	Wabash silt loam.....	39, 040	10. 8
Shelby silt loam.....	49, 536	13. 7	Wabash silt loam, colluvial phase.....	192	. 1
Waukesha silt loam.....	2, 624	. 7	Wabash silty clay loam.....	15, 360	4. 3
Bremer silt loam.....	5, 568	1. 5	Wabash loam.....	896	. 2
Bremer silty clay loam.....	1, 152	. 3	Cass fine sandy loam.....	3, 520	1. 0
Chariton silt loam.....	1, 344	. 4	Cass silty clay loam.....	640	. 2
O'Neill fine sandy loam.....	384	. 1	Genesee fine sandy loam.....	576	. 2
Clinton silt loam.....	41, 088	11. 4	Genesee silt loam.....	320	. 1
Clinton silt loam, shallow phase.....	24, 192	6. 7	Riverwash.....	2, 752	. 8
Clinton fine sandy loam.....	320	. 1			
			Total.....	360, 320	

DARK-COLORED SOILS OF THE UPLANDS AND TERRACES

The soils of this group occur in all parts of the county on flat interstream divides, on gently to moderately rolling slopes, where erosion has not removed the surface layers, and on most of the terraces. An abundant supply of organic matter in the surface layer is a common characteristic of them. The subsoils differ somewhat in color and structure, depending on the parent material and drainage conditions. The surface soils of the Grundy, Muscatine, and Tama soils are heavy silt loams and silty clay loams. The subsoils, which are heavier textured than the surface soils, range from heavy silt loams to silty clays. They are brown, yellowish brown, or mottled gray and brown. The lower subsoil layers, below a depth ranging from 5 to 6 feet, are grayish-yellow or gray floury silt. The Shelby soil has a dark silt loam surface soil and a gritty silty clay loam or silty clay subsoil. The Bremer soils, which occur on low terraces, have almost black surface soils and heavy silty clay loam or silty clay subsoils mottled brown and gray. The Waukesha soil, which also is developed on terraces, has a very dark silt surface soil and a yellowish-brown friable silty clay loam subsoil. The O'Neill soils, also on terraces, are characterized by sandy and gravelly subsoils. Chariton silt loam, developed on terraces, is slightly lighter in color than are the other soils in this group. It is dark-gray silt loam underlain by a 6-inch layer of almost white silt which rests on the heavy mottled gray and brown silty clay subsoil. The principal crops of the county are grown on the soils of this group. Yields are good, but they vary because erosion on some slopes has reduced the thickness of the dark-colored layers and lowered the productivity. All these soils, however, are more productive than the light-colored soils of the uplands and terraces.

Grundy silt loam.—Grundy silt loam is developed on the comparatively narrow flat-topped divides where the original loess plain has not been disturbed by erosion. The surface soil, to an average depth of 10 inches, is very dark grayish-brown friable silt loam. When moist the soil appears almost black. The structure is finely granular, but the granulation is not well developed. Below the surface soil and continuing to a depth of about 22 inches is dark grayish-brown silt loam having a somewhat heavier texture than the soil above and a well-developed granular structure. The next lower layer is the heaviest material of the profile. It consists of dark-colored very granular silty clay, mottled with gray, yellow, and brown. The dark color of the soil particles is due to a coating of black organic matter that has filtered down from the surface layer. The color becomes lighter with depth, and below a depth of 36 inches the material is grayish yellow, with a sprinkling of black concretions and rust-brown iron stains. The surface soil is acid, and, in places, 3 tons of lime an acre are necessary to neutralize the acidity.

Grundy silt loam occurs in areas of irregular shape in nearly all parts of the county except the stream valleys. The longest continuous areas wind along the interstream divides in the south-central part, and large areas are in the vicinities of Melcher, Bussey, and Pella.

Some variations are observed in the profile of Grundy silt loam in different parts of the county. The thickness of the dark-colored surface layer ranges from 8 to 16 inches, depending, generally, on slight inequalities in the surface. The thicker soils are in flat or slightly de-

pressed areas where drainage is slow and vegetation more abundant, and in such areas the texture is slightly heavier than is typical. A gray color is developed in the subsurface layer in some of these areas which, if they were larger, would be mapped as Edina silt loam.

It is presumed that originally the plain on which Grundy silt loam occurs once spread over vast areas of almost level land. As the drainage developed, erosion reduced the size of the flat areas, and drainage conditions now are variable. In all areas, except where the land is extremely flat or depressed, natural drainage is fairly well established. The heavy subsoil prevents the free movement of water and is especially detrimental to good drainage in extensive level areas. Artificial drainage of exceedingly flat fields is necessary in many places before the best yields can be obtained.

This is one of the most productive soils in the county, when properly drained and managed. All the land is cultivated, principally to corn. The average yield of corn is about 45 bushels an acre, but, with good systems of rotation where fields are systematically seeded down, yields of 65 to 75 bushels are obtained. The most common crop rotation is corn, corn, and oats. Occasionally, clover and timothy are seeded in the rotation. Oats yield from 30 to 50 bushels an acre, depending on the management of the soil and seasonal conditions. In extremely favorable seasons 65 to 70 bushels an acre are produced on the better managed farms. Some barley and wheat are grown and yield from 15 to 25 bushels an acre. Hay produces from 1 to 2 tons an acre. Timothy alone and clover and timothy mixed are the principal hay crops.

Grundy silt loam responds quickly to good farm practices. Under proper moisture conditions the soil is handled easily, but it will puddle if plowed too wet, and the lumps bake hard on drying. Continuous cropping to corn and oats has depleted the organic content in many fields, with the result that yields are below the average for this soil. It is very difficult to establish stands of clover. In periods of drought, crop yields are materially lowered in places where the organic content is low. The soil is acid, and lime should be used where alfalfa and other legumes are grown.

The principal need of this soil is the incorporation of organic matter, in the form of barnyard manure and green manure. Applications of phosphorus have proved highly beneficial, especially when used with manure and lime. A 3-year rotation is recommended in fields where the fertility has become depleted.

Muscatine silt loam.—Muscatine silt loam is developed largely in the northern half of the county on flat to gently undulating divides, adjacent to gently rolling or rolling slopes occupied by Tama silt loam.

The surface soil of Muscatine silt loam is very dark grayish-brown finely granular friable silt loam to a depth of 16 inches. The upper subsoil layer, to a depth of about 24 inches, is brown or yellowish-brown silty clay loam stained with organic infiltrations which rather uniformly darken the soil mass. The lower subsoil layer is yellowish-brown heavy silty clay loam mottled with brown, in which some gray and rust-brown iron stains are scattered.

In places where Muscatine silt loam joins Grundy silt loam, the subsoil is heavier and the gray mottling more pronounced. The two

soils occupy similar relief and, as they merge into each other by fine gradations, somewhat arbitrary boundaries are drawn between them in places where they occupy the same divide. The largest area is on a nearly flat divide in the western part of the county, northwest and southeast of Pleasantville. This soil, for the most part, occurs in narrow disconnected strips, as drainage has so dissected the land that only narrow ridge tops remain. Small depressed pockets of silty clay loam, ranging from 1 to 3 acres in extent, are scattered throughout areas of Muscatine silt loam and are included in mapping, as they are too small to be shown legibly.

All the land is under cultivation. The chief crop is corn, yields of which range from 45 to 50 bushels an acre in places where good drainage is established. Yields of 65 to 75 bushels are obtained on the better managed farms. Oats return 35 to 60 bushels an acre, depending on seasonal conditions. Hay crops do well and produce from 1½ to 2½ tons an acre. Alfalfa does well ordinarily, but lime should be used to insure a good stand, as the soil has been leached of lime at all depths.

The first requirement of Muscatine silt loam is adequate drainage, as maximum yields cannot be obtained on undrained areas. When well drained, this is one of the most consistently productive soils in the county. Its response to fertilizers is discussed in the section of this report entitled "Land uses and agricultural methods."

Muscatine silt loam, slope phase.—Muscatine silt loam, slope phase, occurs largely in the southern half of the county, where it occupies gently rolling areas adjacent to and below the flat divides occupied by Grundy silt loam. In general it occupies a topographic position between Grundy silt loam and the lower lying Shelby silt loam.

The surface soil of Muscatine silt loam, slope phase, is dark-brown friable silt loam to an average depth of about 10 inches. Below this is yellowish-brown silty clay loam which changes, at a depth of 24 inches, to yellowish-brown heavy silty clay loam mottled with gray and brown. Numerous rust-brown iron stains are present below a depth of 28 inches.

The color and thickness of the surface soil vary widely, depending on the degree of slope. On gentle slopes under a permanent grass cover, the surface soil is dark grayish brown and is more than 10 inches thick. Here, it approaches the characteristics of typical Muscatine silt loam. In small areas where the surface soil has been thinned by erosion to a thickness of less than 5 inches, the dark material may be mixed by the plow with the underlying grayish-yellow silt, and the surface soil appears lighter brown.

The greater part of the area of this soil is under cultivation. Most of the rest, consisting mainly of the steeper slopes, is in permanent pasture. The relative acreages devoted to the different crops grown are about the same as on the typical soil. Yields are not so high as on typical Muscatine silt loam but, on the average, approach those obtained on Tama silt loam.

Care is required to prevent erosion of this soil. Much sheet erosion already has taken place, and some gullies have cut into the heavy subsoil in places where no measures were taken to prevent erosion. The application of liberal quantities of barnyard manure or the plowing

under of green-manure crops is needed to restore the content of organic matter. Lime, manure, and phosphorus fertilizers will greatly improve crop yields. The frequent growing of clover and turning it under after the second cutting will increase crop yields and lower the tendency of this soil to erode. Some of the more eroded areas should be seeded to grass for permanent pasture or hay land.

Tama silt loam.—Tama silt loam is an extensive soil developed over all parts of the county, except the southern one-fourth. It occupies the rolling upland divides north of Des Moines River and the gently rolling to rolling slopes below the flat upland divides over nearly the entire county.

The surface soil is very dark brown smooth silt loam to a depth of 10 or 12 inches. The subsoil, to a depth of 20 inches, is pale yellowish-brown heavy silt loam somewhat discolored with organic infiltration. The lower part of the subsoil is yellowish-brown heavy silty clay loam faintly mottled with gray at a depth of 28 or 30 inches. Iron stains are numerous in the lower part of this layer. The soil throughout is free from grit or rock, as the soil material is of loessial origin.

Although, in general, the soil is uniform, variations exist in some places. The depth of the surface soil ranges from 6 to 15 or more inches, the thinner soil occurring in the more sloping areas and on the crests of the narrower ridges. Erosion has removed the surface soil in many places. At the bases of some slopes, redeposition of material washed down from higher land has resulted in an accumulation, 18 or 20 inches thick, of the darker colored surface soil. Along Skunk River, where the Tama soils merge gradually with the light-colored Clinton soils, the soil boundaries are necessarily somewhat arbitrary. Here the Tama soils are slightly lighter colored than those on the prairie. Where Tama silt loam joins the Muscatine or Grundy soils, the subsoil is heavier and more mottled than is typical.

The relief of Tama silt loam ranges from undulating to rolling. This soil occupies an upland position intermediate between the flat Grundy or Muscatine soils and the lower lying Shelby soils. Natural drainage is good. On the steeper slopes, the rapid run-off causes erosion if the land is not properly managed, and a cultivated hillside can be ruined by gullies within a short time. The texture and the position on slopes combine to render this soil very susceptible to erosion. The steeper slopes should not be planted to cultivated crops.

Tama silt loam is nearly all in cultivation, and a small proportion is in pasture. In places where the organic matter is not depleted, the soil has excellent moisture-holding capacity. In places where sheet erosion has removed most of the surface soil, crops are affected by drought, whereas in well-managed fields they suffer only slightly.

Drainage is good. Owing to the gently rolling to rolling relief, unless the land is carefully managed, run-off is apt to cause serious sheet erosion and, especially when the organic-matter content is depleted, gullyng. The soil normally is very productive, but continuous cropping to corn and oats on many farms has lowered the organic-matter content until average low yields are obtained.

The soil responds readily to good treatment. A 3-year rotation of corn, small grain, and clover should be used on land that has been cropped too long to corn. Incorporation of organic matter through

heavy applications of barnyard manure and the turning under of green-manure crops will build up the soil and greatly increase crop yields. Where legumes are grown the soil should be limed, as the soil is naturally acid. Experiments indicate that the use of phosphatic fertilizers may prove profitable. Tests should be made with applications of superphosphate and raw rock phosphate on small acreages, in order to determine the profitability of their use. Experiments carried on by the Iowa Agricultural Experiment Station have shown that limestone, manure, and phosphates bring about the best crop yields.

Corn occupies the largest acreage. Yields range from 25 to 50 bushels an acre in normal seasons, depending on the distribution of rainfall and the condition of the soil; yields of 60 to 70 bushels are produced on a few farms where good rotations, including systematic seedings of clover, are practiced. Oats, the second crop in importance, return from 30 to 40 bushels an acre in normal seasons. If periods of drought or if hot dry winds occur when the grain is maturing, yields drop as low as 10 to 15 bushels an acre. Wheat is grown on small acreages, and the average acre yield is between 15 and 25 bushels. Hay is an important crop on this soil and yields from 1 to 2 tons an acre. Mixed timothy and clover is the common seeding, although the use of clover alone is increasing. Lime should be applied at the rate of 2 tons or more an acre to insure best results with clover and alfalfa. Alfalfa is sown mostly in small patches ranging from 3 to 8 acres in size, with oats as a nurse crop. Soybeans are grown to some extent for hay and seed. Other crops of minor importance are rye, barley, sorgo, and millet.

Tama fine sandy loam.—The 8- to 10-inch surface soil of Tama fine sandy loam is dark-brown or dark grayish-brown fine sandy loam. The color is grayish brown on the ridges and knolls in places where the sand is deepest. The upper subsoil layer is grayish-brown fine sandy loam or loamy sand, to a depth ranging from 16 to 24 inches, grading into yellowish-brown sandy clay loam. On a few ridges the lower subsoil layer is yellowish-brown fine sand or sand to a depth of 45 or more inches. In other places, the sandy layer is thin and rests on loess.

The variation in thickness of the sandy surface layers of this soil may be explained by the method of its formation. Loosely cemented sandstone strata were exposed in places in the beds of the larger streams. As these sandy rocks disintegrated, the released sand was carried by the wind and spread as a mantle over the loess of the upland. The sand was unequally distributed and formed a layer of varying thickness. More or less loess carried with the drifting sand has produced a variation in composition. Over the greater part of these areas the thickness of the sandy layer ranges from 3 to 18 feet. Along the borders of the areas, however, the sand deposit was only a few inches thick, and it has been mixed with the underlying loess.

This soil occurs in only three areas, the largest of which is in the extreme northeastern corner of the county, $6\frac{1}{2}$ miles northeast of Pella; the other two are in the north-central part, north of Knoxville and south of Des Moines River.

Areas of this soil are undulating or gently rolling. Drainage ranges from good to excessive. In dry periods, when the land is freshly plowed or exposed without a vegetative cover, the surface soil is subject to some blowing. This shifting generally is restricted to distances of only a few feet, however. The lighter colored spots where organic matter is badly depleted move most readily. Corn may be damaged by soil blowing in the first stages of growth.

Corn, oats, and hay are the chief crops grown on this soil. Yields are considerably lower than on Tama silt loam, except on the areas adjoining Tama silt loam, where the sandy loessial mantle is shallow—or only from 6 to 18 inches thick. Here crops, in favorable seasons, produce yields comparable to those obtained on the associated Tama silt loam. Clover will do well in places where lime is used.

This soil is easy to cultivate. Owing to its open porous structure, it warms early in the spring. This soil is particularly adapted to truck crops and melons. More organic matter is needed commonly in the soil to increase the moisture-holding capacity, supply plant nutrients, and reduce shifting of the surface soil.

Shelby silt loam.—The surface soil of Shelby silt loam is dark-brown or dark grayish-brown silt loam containing a small quantity of sand. The thickness of the surface layer depends on the activity of erosion or deposition. On the steeper slopes the dark organic layer is as thin as 5 inches or less, but on the smooth nearly level virgin areas it is as much as 12 inches thick. The surface layer is underlain by yellowish-brown or reddish-brown gritty clay loam. Faint gray mottlings appear in places at a depth of 24 inches. Below a depth of 30 inches, the gray shade increases and the texture in most places is heavier. Coarse sand, gravel, and boulders become more abundant with increase of depth and reach a maximum concentration between depths of 30 and 40 inches. The stone fragments are not segregated in loose beds but are embedded in the heavy till. Splotches and streaks of soft lime are present in many places below a depth of 40 inches. The surface soil is leached of lime and is medium acid.

Shelby silt loam occurs in winding and generally narrow bands along stream slopes in nearly all parts of the county. It is developed where the streams have cut through the loess cap and exposed the glacial till. The width of the strip of Shelby soil depends on the thickness of the drift sheet and the angle of the slope. Comparatively gentle slopes have a wider outcrop of the till. Most areas of this soil are developed in a position below the Muscatine or Tama soils of the loess capping and the Lindley soils of the lower slopes. The content of silt is due in large part to silty material washed down from the loessial soils.

Shelby silt loam almost invariably occurs on slopes which range from gentle to moderately steep. Drainage is good and, in places, excessive. Although this soil is not so erosive as the more silty soils, erosion has been comparatively rapid in some places where the land is poorly managed, owing to the slopes. Where no measures have been taken to protect the soil, sheet and gully erosion have taken a serious toll of the surface layer. The yellow subsoil has been exposed in numerous spots, ranging from 1 to 3 acres in size, in cultivated fields. The farmers have discontinued their attempts to grow cul-

tivated crops on much of this land. Probably three-fourths of the land has been under cultivation, but at present only about 40 percent is cultivated.

Corn returns from 30 to 40 bushels an acre on the better fields. Oats and hay yield well on the noneroded areas. It is not economically sound to attempt cultivation in badly eroded fields in which the subsoil is exposed in many places. Lespedeza, clover and timothy, or mixed grasses should be seeded and left permanently on the poorer lands. Bluegrass once grew luxuriantly on this soil, and much of the land now cultivated should be seeded to this grass.

Seepage spots are numerous on slopes. These spots are unproductive and are hard to plow or cultivate, as the plows will not scour. Placing tile above the seepage spot is the most effective method of draining these areas.

The greatest need of much of this soil is organic matter and the growing of leguminous and grass crops. Plowing and cultivating on the contour, strip cropping, and systematic seeding with a 3-year rotation and permanently seeding depleted fields to permanent grass are recommended. Natural drainageways on slopes should be seeded permanently to grass to prevent gullying.

Waukesha silt loam.—The surface soil of Waukesha silt loam is dark grayish-brown or almost black friable silt loam with an average thickness of 15 inches. It is underlain to a depth of 22 inches by yellowish-brown light clay loam containing occasional streaks of dark organic matter. Below this is yellowish-brown silty clay loam which becomes faintly mottled with gray below a depth of 30 inches. The subsoil is not calcareous, and the surface soil in most places is acid. The subsoil is moderately heavy but not impervious. The moisture-holding capacity of this soil is excellent.

Waukesha silt loam is developed in several comparatively small bodies on flat terraces that stand well above overflow, principally along Whitebreast Creek and Skunk River. None of these bodies exceeds 1 square mile in area. The position of this soil and its pervious character insure good drainage in both surface soil and subsoil.

The natural fertility of this soil is high. Practically all of the land is under cultivation. It is cropped heavily to corn. This is partly due to the fact that the farm land below it is overflowed and much of the upland above it is hilly and not cultivable. Yields of corn range from 30 to 60 bushels an acre, depending on the condition of the soil and the season. Oats return 35 or 40 bushels. This soil needs the incorporation of more organic matter than is provided by manure, in order to maintain its high level of fertility. Clovers should be grown in rotation and the second crop turned under. The increase in the corn yields following a legume crop will give a greater return in the long run. The soil is acid and should be limed especially for the growing of legumes.

Bremer silt loam.—Bremer silt loam occurs on low terraces, principally along Des Moines River, Skunk River, and Whitebreast Creek. Ordinarily, it occupies a position from 2 to 5 feet above the first bottoms. The land is flat or very gently sloping toward the streams.

The 10-inch surface soil is dark grayish-brown silt loam which

appears black when wet. Below this and continuing to a depth of 18 or 20 inches is dark-gray silty clay loam. The lower part of the subsoil is gray silty clay mottled heavily with yellowish brown and brown, with many rust-colored and orange-brown iron stains. The material in this layer is very heavy and almost impervious. Some variation occurs in the texture of the surface soil. The soils of small depressed circular pockets or narrow swales, which are too small to separate on the map, consist of silty clay loam. Considerable very fine sand is mixed with the surface soil which, in some places, has a loam texture. The reaction ranges from slightly to moderately acid.

Natural drainage ranges from fair to poor, and some artificial drainage is needed over much of the area to insure maximum crop yields. Open ditches are used on a few farms to aid in drainage, and a few fields are tiled.

Most of this soil is cultivated. Corn is grown continuously on much of the land, with an occasional change to small grains. In favorable seasons corn yields from 40 to 50 bushels an acre. Oats yield from 30 to 55 bushels. Some wheat is grown, and yields ranging from 18 to 30 bushels are obtained. Seasonal conditions largely determine the yields of grain. If the weather is extremely hot during the dough stage, yields of small grain are cut severely. Hay produces from 1 to 2 tons an acre. The use of definite rotations, which include systematic seeding and the plowing under of a green-manure crop, is needed on this soil.

Bremer silty clay loam.—The surface soil of Bremer silty clay loam is dark grayish-brown or black silty clay loam to a depth of 16 inches. When wet, it is black and very sticky. The upper part of the subsoil, which extends to a depth of 24 inches, is dark-gray silty clay streaked and darkened by the infiltration of organic matter. The lower subsoil is gray silty clay mottled with rust-brown iron stains and concretions. This soil must be plowed and cultivated under proper moisture conditions; otherwise, it will bake and clod on drying. In dry seasons, large deep cracks form, which cause the soil to dry rapidly.

This soil is closely associated with Bremer silt loam, but it occupies slightly lower positions on flat benches which are only a few feet above the first bottoms. This is not an extensive soil. It occurs principally in small areas along Des Moines and Skunk Rivers. Most of the land is under cultivation, and cropped largely to corn. Slough-grass grows in some areas that are too wet to cultivate. In dry years, crop returns are about the same as on Bremer silt loam, but in wet seasons low yields are obtained. The incorporation of organic matter improves the physical condition of this soil, especially the tilth and drainage. Poor natural drainage is the limiting factor in the production of crops. Open ditches would improve this condition somewhat.

Chariton silt loam.—Chariton silt loam is developed in small areas, mostly along Whitebreast and Cedar Creeks. A fairly large area is 3 miles north of Knoxville, and others are west of Bussey. The soil occupies flat terrace benches lying well above overflow.

The surface soil is dark grayish-brown smooth silt loam to a depth of 8 or 10 inches. It appears to be very dark gray when wet and

gray when dry. This layer is underlain by a 4- to 8-inch layer of light-gray or ash-gray floury silt loam which is compact in place but breaks to a loose mass. Black iron pellets are abundant in the layer. The subsoil is gray clay, in which yellowish-brown and black mottlings and rust-brown iron stains are numerous. The lower part of the subsoil, below a depth ranging from 30 to 36 inches, contains more gray and less yellow than the material above.

Included with this soil on the map are a few small areas which differ from it in several respects. The color of the surface soil is gray or light gray. In the field, when thoroughly dry, it appears gray or very light gray. The subsoil is more gray and is slightly heavier than that of typical Chariton silt loam. It is a heavy waxy clay. If these areas were more extensive, they would be mapped as Calhoun silt loam.

Drainage is fair in the surface soil, but the heavy compact subsoil is highly impervious. The entire soil is leached of carbonates and is strongly acid.

Practically all of this land is cultivated, mainly to corn and small grains. Crop yields are lower than on Bremer silt loam. The surface soil is low in organic matter, and applications of barnyard manure or the incorporation of green-manure crops are needed, in order to increase the fertility. Clover and timothy are used for seeding in a few fields, and they do well.

O'Neill fine sandy loam.—A few very small isolated bodies of O'Neill fine sandy loam lie along Des Moines and Skunk Rivers bordering the uplands. This soil occupies terrace benches well above overflow.

The surface soil is dark-brown fine sandy loam which changes, at a depth ranging from 8 to 20 inches, to brown fine sandy loam. Below this the soil material is yellowish-brown fine sand. The surface soil ranges in texture from loam to fine sandy loam. On slight rises or hummocks the texture is loamy sand. One area $5\frac{1}{2}$ miles west of Bussey on North Cedar Creek, included with this soil, has a light-colored surface soil of grayish-brown fine sandy loam. Owing to the loose porous substratum, this soil has a poor moisture-holding capacity and is droughty. The soil is slightly to medium acid.

All the land is used for the production of crops, chiefly corn and oats. The soil warms early in the spring, and crops make a rapid growth and mature earlier than on the heavier soils. Small grains are best adapted to this sandy soil because they mature before the hot dry weather.

Organic matter is the greatest need of this soil. The turning under of legumes or other green-manure crops will help maintain the fertility.

LIGHT-COLORED SOILS OF THE UPLANDS AND TERRACES

The light-colored soils of the uplands and terraces occur chiefly on stream slopes and on the adjacent gently rolling ridges. As the light color indicates, the organic-matter content in these soils is low. They have developed under a forest cover where conditions were not favorable for the accumulation of large quantities of organic matter. The gray Putnam soils, developed on flat upland divides, are intermediate in color between the light- and dark-colored soils.

They are classed with the light-colored soils, to which they bear a closer resemblance than they do to the dark-colored soils. A distinguishing characteristic of these soils is the presence of a 2- to 10-inch layer of almost white silt beneath the surface soil. The Clinton, Weller, and Lindley soils are light-colored upland soils developed on slopes. Jackson silt loam is developed on flat benches well above overflow and, originally, was covered with forest.

Only a comparatively small proportion of these soils is cultivated. Corn is not so well adapted to these soils as to the dark-colored soils, but nevertheless it is the chief crop. Small grains do well. Additions of organic matter, in the form of green-manure crops or barnyard manure, are necessary to produce satisfactory yields. Areas not cultivated are used for pasture or wood lots.

Clinton silt loam.—Clinton silt loam is an extensive soil and is widely distributed over almost the entire county. It occupies the more rolling lands and dissected valley slopes adjacent to the major streams and their tributaries. The largest development is in the northwestern part, north of Des Moines River. The soil was developed from loess under a forest cover consisting principally of white oak, red oak, hickory, and elm, together with other hardwoods.

The 8- or 10-inch surface soil of Clinton silt loam is grayish brown or light brown. When dry, it appears light gray or almost white. The upper part of the subsoil is pale yellowish-brown silty clay loam which changes, at a depth of 18 or 20 inches, to yellowish-brown silty clay or clay mottled in the lower part with some gray splotches and many rust-brown iron stains. Below a depth of 38 or 40 inches the gray predominates. At a depth of about 45 inches the material becomes slightly lighter in texture, but the color remains the same as in the overlying layer. The soil is thoroughly leached throughout the profile, and both surface soil and subsoil are strongly acid.

The surface soil varies considerably in thickness. On areas with rolling relief, the surface soil averages about 6 inches thick, whereas, on the more level ridge tops it ranges from 10 to 14 inches in thickness. The cultivated slopes are subject to erosion unless carefully managed, and, in places, the original surface soil has been removed. Many fields have been abandoned and are severely gullied. Along streams and extending back up deep ravines, the slopes are rough and broken.

Probably 40 percent of this land is farmed to the crops commonly grown throughout the county. Corn is the principal crop, although the farmers realize that this is not a good soil for corn. Small-grain and hay crops do well where erosion is controlled. On eroded slopes where the yellow silty clay subsoil is exposed, both grain and hay crops produce little in dry seasons. Corn yields from 20 to 40 bushels an acre on undulating or gently rolling areas. Where a part or all of the subsoil is exposed, yields are much lower. Higher yields are obtained where rotation and frequent seeding are practiced. Oats, barley, and wheat produce from 20 to 45 bushels an acre, depending on management and the condition of the soil. Timothy and clover yield 1 to 1½ tons of hay. The available barnyard manure is not adequate to supply the deficiency of organic matter in this soil. Green-manure crops should be grown systematically and

turned under. Corn should not be grown 2 years in succession. A 3-year rotation is recommended, consisting of corn, small grain, and clover, the second crop of which should be turned under. Where clover is grown, lime should be applied as the soil ordinarily is strongly acid. This soil responds to phosphate fertilizer, but the economic value of this amendment should be tested on small acreages before using. It is suggested that the land on cultivated slopes be plowed and farmed on the contour. Strip cropping, with strips narrow enough to protect the slopes from washing, may prove to be practical on this highly erosive soil. Where the land is clean cultivated, sheet erosion may be rapid and may be followed by gullies. Therefore, great care must be taken to prevent soil losses. The steeper slopes should be kept permanently in grass, and only the undulating or gently rolling areas should be cultivated. Seriously eroded areas generally cannot be cultivated with satisfactory results.

Clinton silt loam, shallow phase.—Areas in which a thin covering of silty material overlies bluish-gray or gray shale are mapped as a shallow phase of Clinton silt loam.⁵ The entire area formerly was forested, but only a few of the trees remain.

The surface soil of this shallow soil is grayish-brown friable silt loam having an average thickness of 8 inches. When wet the soil appears light brown, but it dries to a gray shade and, in places, becomes almost white. The surface layer is underlain by yellowish-brown coarsely granular silty clay loam. Below a depth of 18 inches, the soil material is yellowish-brown silty clay loam mottled with orange and rust-brown stains. The silty soil layers are underlain by gray or light-gray clay developed from shale. Many variations may be observed, especially in the thickness of the soil layers over the bedrock. The loess covering ranges from a few inches to more than 3 feet in thickness. The material in the lower part of the soil varies in composition, depending on the proportion of the material that has weathered from the shale and the character of the shale.

This soil occurs in narrow ribbonlike strips along the lower slopes of the deeper stream valleys. It is most extensively developed along English Creek south of Knoxville, and along Cedar Creek in the southeastern part of the county. Generally, only a small acreage of this soil is included in any one farm.

This soil erodes rapidly under clean cultivation, owing to the nature of the soil and to its position on slopes. A large proportion of this land, formerly cultivated, is now abandoned.

Only a small proportion of the land, principally in the area south of Knoxville, is cultivated. Corn and small grains are the chief crops. Corn produces from 15 to 35 bushels to the acre, depending on the thickness of the soil and the smoothness of the fields. The greater part of this soil should be kept in grass for pasture.

Clinton fine sandy loam.—Clinton fine sandy loam occurs in only one area which lies $1\frac{1}{2}$ miles northeast of Harvey on the north side of Des Moines River.

The 8- or 10-inch surface soil is grayish-brown fine sandy loam or loamy fine sand. It is underlain by yellowish-brown uniformly fine

⁵ Since the soil survey of Marion County was completed it has been found necessary in other surveys to establish a new series to include soils similar to Clinton silt loam, shallow phase. In future investigations, soils of the general character of this phase will be designated Gosport silt loam.

sand. The lower part of the subsoil, below a depth ranging from 20 to 30 inches, is yellowish-brown fine sand or fine sandy loam, containing a high proportion of fine sand. There is considerable variation in the texture of both surface soil and subsoil. On some ridges and knolls the surface soil is loamy sand or sand. Yellowish-brown unconsolidated sand continuing to a depth of 4 feet or more forms the subsoil in places.

The relief is gently rolling or rolling, and drainage ranges from good to excessive. The origin of this soil is similar to that of Tama fine sandy loam. The fine sand accumulated in the river bed through the disintegration of sandstone and was then carried by the wind and deposited over the upland.

Corn and small grains are grown. In wet seasons fair crops are produced, but in seasons when moisture is deficient crops burn badly. Corn yields from 15 to 30 bushels an acre and small grains about the same. The growing of watermelons and cantaloups is commercially important. With the incorporation of sufficient organic matter, fair crops can be produced. Barnyard manure and green manures are needed to increase the moisture-holding capacity of this soil. All crops would benefit by additions of manure, lime, and phosphate.

The results of mechanical analyses of four layers of Clinton fine sandy loam are given in table 6.

TABLE 6.—*Mechanical analysis of Clinton fine sandy loam*

Sample No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Percent	Percent	Percent	Percent	Percent	Percent	Percent
338588.....	Surface soil, 0 to 6 inches.....	0.0	2.4	20.1	56.7	5.3	11.1	4.4
338589.....	Subsurface soil, 6 to 24 inches.....	.1	2.4	21.3	57.2	5.2	9.3	4.5
338590.....	Subsoil, 24 to 32 inches.....	0	2.0	19.5	57.0	5.0	9.7	6.8
338591.....	Subsoil, 32 to 48 inches, +.....	0	1.9	20.3	57.1	5.4	8.3	6.9

Putnam silt loam.—Putnam silt loam is developed in a few small bodies in the extreme southeastern part of the county, where it occupies flat areas on the upland divides, lying between areas of Grundy silt loam and the rolling Clinton silt loam.

The 8- or 10-inch surface soil is grayish-brown or dark grayish-brown smooth silt loam. It is underlain by a layer of light-gray floury silt loam from 5 to 10 inches thick. Iron pellets and some soft iron accumulations impart a mottled appearance to this intermediate layer. The subsoil is gray heavy plastic clay mottled with darker gray, yellowish brown, and rust brown, and with black iron stains. Below a depth of 4½ or 5 feet, the subsoil consists of mottled gray, yellowish-brown, and brown silty clay loam containing a high percentage of silt.

Natural drainage is poor because of the flat surface and impervious subsoil. Crops are adversely affected, both in dry and wet periods, as the ground cracks and dries under droughty conditions and dries too slowly after saturation by rain water. This soil is difficult to drain artificially. Practically no tile is used.

All the common farm crops are grown. Small grains do better on this soil than does corn. The yields of oats and barley range from

15 to 35 bushels an acre. It is very difficult to establish a stand of clover on this soil because of poor drainage and high acidity. Timothy does well and yields about 1½ tons of hay to the acre, but it is grown mainly for seed.

Weller silt loam.—The surface layer of Weller silt loam is grayish-brown or rather dark grayish-brown smooth silt loam to an average depth of 10 inches. Underlying this is yellowish-brown heavy silty clay loam. The soil aggregates are sprinkled or coated with gray, which is very apparent when the material is dry. Beginning at a depth of 20 inches, the lower subsoil layer is tough yellowish-brown silty clay or clay, mottled with gray and brown. Many iron stains and concretions appear in the subsoil, especially below a depth ranging from 24 to 36 inches. Below a depth of 38 or 40 inches is heavy but friable gray or pale-yellow silty clay loam mottled with gray and with yellowish-brown and rusty-brown iron stains.

This soil occupies rolling to hilly areas along the larger tributaries, principally in the southeastern part of the county. Most of the slopes are steep and the ridges narrow. Thin stands of oak and other hardwood trees, in addition to hazel brush, cover some slopes. Originally, this land was covered largely with scattered oak, hazel, and buckbrush.

The depth of the surface soil is variable. Unless carefully managed, Weller silt loam, when cultivated, erodes seriously, owing to the loose silty surface soil and heavy impervious clay subsoil, and in many places on narrow ridge tops and steeper slopes the original surface soil has been removed by erosion.

Probably not more than one-third of this land is in cultivation. On the gentler slopes or ridges, where the soil is sufficiently deep, small grains produce from 10 to 30 bushels an acre. Stands of clover and timothy, once established, produce good hay crops and pasture. Corn is grown in small patches, but yields are low, ranging from 15 to 35 bushels an acre. Most of this soil is best suited to permanent pasture. The soil is acid and needs liming for the growing of legumes, and additions of organic matter are needed on cultivated areas. The use of phosphate fertilizers also will improve crop yields.

Lindley silt loam.—Lindley silt loam occurs along most of the larger streams throughout the county in hilly and broken areas, generally on the steeper slopes which are uncultivable. The parent materials of this soil are derived from loess overlying Kansan drift.

The surface soil of Lindley silt loam is grayish-brown floury silt loam to a maximum depth of about 10 inches on the lower slopes. In other places, the loess covering is very thin, and the subsoil material is exposed on many of the upper slopes. The surface soil is underlain by yellowish-brown gritty silty clay to a depth ranging from 18 to 24 inches. Below this is yellowish-brown or yellow clay mottled with gray, brown, and many rusty-brown iron concretions and stains. This lower layer contains much fine sand and a few boulders. The soil is highly acid.

Only a small part of this land is cultivated. The gentler slopes have been cleared on some farms, forming small irregular fields, in which corn, oats, and hay are grown. The natural fertility is low. Small grains and hay are the crops best adapted to this soil. Most of the land is too steep for cultivation. The original timber has been

removed from a large part of the land for use as posts, mine props, and rough lumber for farm buildings. The cut-over land is pastured but affords meager grazing, as the dense second growth of sprouts checks the growth of grasses. In thinly forested areas, bluegrass does well.

Jackson silt loam.—Jackson silt loam is of minor agricultural importance as its total area is small. The largest two bodies are along English Creek in the vicinity of Durham, and along Whitebreast Creek northwest of Knoxville.

The surface soil of Jackson silt loam is brown or grayish-brown silt loam with an average thickness of about 10 inches. The upper subsoil layer is light-brown heavy silt loam which, in places, is streaked with gray. Below a depth of 22 inches, the lower subsoil layer is, in most places, brown silty clay faintly mottled with yellow and gray.

Jackson silt loam occurs on well-drained terraces above the flood stages of the streams. The relief is level or undulating. A hardwood forest formerly covered the land, but only a few trees remain.

The profile of this soil is not greatly different from that of Clinton silt loam of the rolling uplands. The smooth relief, however, gives it an advantage over that soil in the proportion of land that can be cultivated. Its fertility is, of course, inferior to that of the dark-colored Prairie soils. Yields of corn range from 20 to 30 bushels to the acre. Oats and timothy and clover are grown, and yields of these crops are about the average for the county.

SOILS OF THE BOTTOM LANDS

For the most part, the soils of the bottom lands in this county are dark colored. Very dark colored surface soils and heavy silty clay loam or silty clay subsoils characterize the Wabash soils. Cass silty clay loam and Cass fine sandy loam also have dark-colored surface soils but differ from the Wabash soils in having sandy subsoils. The lighter colored bottom-land soils are represented by the Genesee soils. Riverwash consists of light-colored unconsolidated sand which is worthless for agricultural purposes. With the exception of Wabash silt loam, colluvial phase, the soils of the bottom lands are subject to periodic overflow which, at times, causes considerable crop damage.

Wabash silt loam.—Wabash silt loam is developed along the larger streams and their tributaries in all parts of the county. It is the most extensive soil of the first bottoms.

The 15-inch surface soil is dark grayish-brown or almost black silt loam. The upper subsoil layer is gray silty clay loam, and the lower subsoil layer, below a depth of 22 or 24 inches, is lighter gray silty clay loam mottled with brown, yellowish brown, and many rust-brown iron stains. A considerable variation in the texture of the surface soil exists. The proportion of sand is generally higher near the stream channel than it is farther back, and the texture is nearly that of loam. Light-colored silt and sand has been carried into the bottoms by small streams issuing from the surrounding hills or has washed down from adjoining upland slopes. Areas of Wabash silty clay loam, too small to indicate separately on the soil map, have been included with Wabash silt loam.

Areas of Wabash silt loam are flat or slope gently toward the streams. The land lies only a few feet above the level of the streams and is subject to periodic overflow. Overflows are more frequent along the smaller tributaries. As a rule, the floodwaters recede quickly, and, during ordinary floods, the bottoms are inundated for only a short time. In low swales or pockets water remains for some time.

This soil occurs in strips from one-eighth to one-half mile wide. Many of the wider areas are in cultivation, and the narrower strips along the smaller streams are in permanent pasture. Scattered trees and brush grow in places along streams where the land never has been cultivated, and bluegrass is abundant in unshaded areas. Corn is the principal crop and produces well when not damaged by floodwaters. Yields ranging from 40 to 60 bushels an acre are obtained in favorable seasons. Oats yield from 40 to 45 bushels under normal conditions. All the grain is used on the farms where it is produced. Hay crops do well and yield from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons an acre.

This soil is high in natural fertility and will stand continuous cropping to corn for long periods, without much decrease in yields. Owing to its mellowness, the soil is easy to till. It should not be plowed when too wet, however, as it is likely to become cloddy. The plowing under of green-manure crops has a very beneficial effect. Drainage is the principal problem on the land. Open ditches are a help in carrying off the water more quickly.

Wabash silt loam, colluvial phase.—The colluvial phase of Wabash silt loam is developed over an accumulation of rich dark-brown or black alluvium which has been washed down from the uplands and deposited at the heads of drainageways, mainly in the northwestern part of the county. Owing to its very small extent, this soil is of minor importance.

The 14- to 22-inch surface soil is dark grayish-brown or black heavy silt loam. The texture of this layer varies; in some places it is silty clay loam, whereas in other places sand and light-colored silty clay materials have been washed from a few steep slopes, resulting in a mixed loam texture. The upper subsoil layer is dark-gray or grayish-brown silty clay loam mottled with rust-brown iron stains. The lower subsoil layer, below a depth of 30 inches, is light-gray or grayish-brown silty clay loam mottled with brown and yellowish brown. Many soft rust-brown stains and concretions are present in the lower part of the subsoil.

Natural drainage ranges from fair to good. The draws occupied by this soil have a 3- to 5-percent slope, so that water is carried away rapidly, and the damage caused by flooding is slight. The high content of humus and the porous structure impart excellent moisture-holding properties to the soil.

This soil is best adapted to the production of corn and hay. Small grains make a rank growth and are likely to lodge. Hay crops, especially timothy and clover, return yields far above the average for the county.

Wabash silty clay loam.—Wabash silty clay loam is extensively developed on the bottoms of Des Moines and Skunk Rivers and to less extent along the larger creeks. It occupies flat or depressed

basinlike areas ranging from one-eighth mile to 1½ miles or more in width.

The surface soil is very dark grayish-brown or black heavy silty clay loam, about 16 inches thick. The subsoil is dark grayish-brown silty clay which gradually becomes lighter with depth and changes, at a depth of 22 or 24 inches, to gray silty clay loam or silty clay, mottled somewhat with lighter gray, brown, and yellowish brown. Iron stains and concretions are abundant in the lower part of the subsoil. In some places the surface soil is extremely heavy and approaches a silty clay in texture. Where this soil joins Cass fine sandy loam, the surface soil is sandy clay loam or clay loam, as the transition between the two soils is gradual. The carbonates have been removed through leaching, and both surface soil and subsoil are slightly acid.

Natural drainage is slow, owing to the relief and to the heavy waxy subsoil.

Most of the land is cultivated. Corn is grown continuously in rotation with small grain. It produces from 40 to 60 bushels an acre in normal seasons. Wheat is grown extensively and yields from 15 to 30 bushels an acre. In wet seasons, small grains make a rank growth and are apt to lodge. Hay crops, principally clover and timothy mixed, yield 1½ or 2 tons an acre. Grain yields are lower on the average than those obtained on Wabash silt loam, because of the restricted drainage. The highest yields are obtained in seasons of low rainfall.

The plowing under of green-manure crops and stubble will improve the physical condition of this soil. Open ditches placed at intervals through fields will greatly aid in drainage. Tile is very effective, but its use is limited because of the expense.

Wabash loam.—Wabash loam is developed principally along Des Moines River in narrow strips lying near the stream channel. It covers only a small total area.

The surface soil is dark grayish-brown friable loam, 12 or 14 inches thick. The upper subsoil layer, to a depth of about 22 inches, is dark-brown loam. The lower subsoil layer is brown or dark grayish-brown clay loam mottled with brown or yellowish brown. Some rust-brown iron stains are present in the lower part. Much sand and some small gravel are scattered through the entire profile.

There is considerable variation in the texture of the surface soil. The soil lying along the river bank is more sandy than the typical soil, and small areas are sandy loam or loamy sand. The subsoil under some small mounds and ridges is yellowish-brown sand. These areas would have been mapped with the Cass soils, had they been of sufficient size.

Corn is grown almost continuously, with an occasional crop of small grain. Average yields of corn in different years range from 35 to 50 bushels an acre. This soil is easy to work and can be handled under a wide range of moisture conditions. It is subject to periodic overflow.

Cass fine sandy loam.—The surface soil of Cass fine sandy loam, to an average depth of about 10 inches, consists of dark grayish-brown loose fine sandy loam. The upper subsoil layer, to a depth of 22 inches, is brown or grayish-brown fine sandy loam containing a

larger proportion of clay than does the surface soil. The lower subsoil layer is grayish-yellow or yellowish-brown loose fine sand. There are a few variations in the texture and thickness of the surface soil. In depressions and flat areas, the texture is heavier and, in places, approaches a loam. On low mounds or ridges near the streams, the soil covering is loamy sand. Although the soil is open and porous to a depth of several feet, crops do not suffer from lack of moisture in normal seasons, as the water table is near the surface. The soil is neutral or slightly acid throughout.

Cass fine sandy loam is a soil of the first bottoms. It occurs in a number of areas along Des Moines River and in one small area on Skunk River. The bodies follow the river in winding strips, and, in places, they are more than one-half mile wide. This soil lies near the river, but, in most places, it is separated from the stream by a strip of sandy and gravelly riverwash. The land is subject to occasional overflows, but the surplus water quickly passes off through the porous subsoil.

Nearly all of the land is under cultivation. The organic content of many fields is depleted, and the Cass soil is less productive than Wabash silt loam. Corn is the principal crop on the Cass soil in places where the water table is not too near the surface. Yields range from 20 to 45 bushels to the acre.

Cass silty clay loam.—Cass silty clay loam is a first-bottom soil occupying a few isolated bodies ranging from 50 to 300 acres in area, along Des Moines River.

The 12- or 14-inch surface soil is dark grayish-brown or black silty clay loam. It is underlain by dark-gray heavy silty clay loam which changes, at a depth of about 20 inches, to light-gray silty loam mottled with brown and yellowish brown. Some rust-brown iron stains are present. Below an average depth of 26 inches, the soil material is grayish-brown or yellowish-brown sand containing some clay. The depth to the sandy subsoil varies considerably. On gently rounded ridges along old sloughs and in the areas near the main river channels, the sandy subsoil layer lies at a depth of 22 or 24 inches below the surface. In places where the land is flat, the heavier overlying soil layer reaches a depth of 28 or more inches. Considerable sand is mixed with the surface soil in narrow strips which adjoin the loose sand and gravel deposits along the riverbank. The texture in this transitional zone is clay loam or sandy clay loam. The soil is neutral or very slightly acid throughout.

This soil is not so poorly drained as are the surrounding areas of Wabash silty clay loam, owing to the loose sand of the subsoil. Drainage, however, is restricted, and crops may suffer some injury on the flat areas in periods of heavy rainfall.

Cass silty clay loam is a fertile soil, and in favorable seasons it produces yields comparable to those obtained on Wabash silt loam. Wheat does well and yields from 15 to 30 bushels an acre, depending on weather conditions. Acre yields of clover and timothy hay range from 1 to 2 tons.

This soil must be handled under optimum moisture conditions, otherwise it will bake and clod. The surface soil needs the incorporation of green-manure crops and stubble to improve the tilth.

Drainage is a major problem on this soil and may be improved greatly by the construction of open ditches.

Genesee fine sandy loam.—The surface soil of Genesee fine sandy loam, to an average depth of 10 inches, consists of grayish-brown fine sandy loam. It is underlain by brown or yellowish-brown silty clay loam containing considerable fine sand. Below a depth of 20 inches the yellowish-brown silty clay loam continues with a larger or smaller proportion of fine sand. This soil differs from Genesee silt loam mainly in having a larger proportion of sand in the upper layers.

This soil occupies a small total acreage. It occurs in a few small areas at the bases of slopes bordering the Des Moines River bottoms. The lower areas are flooded when the river is exceptionally high; but both surface and subsoil drainage are good, so that the water is removed quickly from the land.

It is difficult to estimate crop yields, as strips of this soil generally are farmed in connection with the adjoining more productive soils. The yield of corn is slightly lower than that on Genesee silt loam. The average acre yield of corn in favorable seasons probably does not exceed 30 bushels.

Oats are grown to a small extent, with yields of about 20 bushels an acre. Organic matter should be supplied by the application of stable manure or by the plowing under of green-manure crops.

Genesee silt loam.—Genesee silt loam is a soil of small extent. It occurs in a few narrow disconnected strips, principally along Des Moines River. The soil materials are light-colored loessial silts washed down from the nearby hills and upland slopes. The largest area mapped lies 6½ miles north of Knoxville along Des Moines River.

The surface soil is grayish-brown silt loam containing a large proportion of very fine sand. The subsoil, beginning at a depth of 12 inches, is yellowish-brown or grayish-yellow heavy silt loam or silty clay loam, which also contains a large proportion of very fine sand. There is some variation in both the color and the texture of this soil. Along the boundary where the Genesee soil joins the darker colored Wabash soils, the surface soil is darkened by a mixture of darker materials. In places the surface soil is very fine sandy loam. Thin layers of very fine sand or very fine sandy loam are present in the subsoil in places.

The relief of this soil is flat, and natural drainage ranges from fair to good. Yields of corn average lower than on the darker colored Wabash and Cass soils, with which this soil is farmed, as the organic-matter content and natural fertility are very much lower than in those soils. Green-manure crops should be grown and plowed under, in order to increase the organic-matter content and build up the fertility of the soil.

Riverwash.—Riverwash consists of loose sands and gravelly materials carried out of the channel by high floodwaters of streams and deposited in strips from 50 to 500 feet wide along the banks. This loose unconsolidated material is reworked at every flood stage. It has no value as crop or pasture land. The sand and gravel are used, however, for road and building materials.

LAND USES AND AGRICULTURAL METHODS

Marion County had a total of 344,383 acres in farms in 1935, according to the Iowa Year Book.⁶ Of this, 170,529 acres, or 49.5 percent, were in crops, represented by 23.54 percent in corn, 10.91 percent in oats, 10.03 percent in tame hay, 2.47 percent in winter wheat, and the remaining 2.56 percent in rye, soybeans, barley, and miscellaneous crops. The rest of the land included in farms is represented by 38.8 percent in pasture, 4.83 percent idle cropland, 4.1 percent in roads, feed lots, and buildings, 1.11 percent in wood lots, 0.04 percent in wild hay, and 1.11 percent waste land.

Corn is the chief crop, and farm operations center largely around its production. It is grown on every soil in the county to some extent. The raising and feeding of hogs and cattle is the principal livestock industry. Some dairying is carried on. With the exception of wheat, almost all of the grain grown on the farm is fed to livestock.

In 1935, corn was grown on 81,073 acres and the average yield was 36.5 bushels an acre. The average acre yields for counties in the south-central part of Iowa ranged from 17.5 bushels to 38.1 bushels, and the average yield for the State was 38.4 bushels for that season.

Land to be planted to corn is plowed either in spring or in fall. Soils of the gently undulating and flat uplands and of the flat first and second bottoms are plowed in fall. Soils on the more hilly lands are plowed largely in spring, in order to avoid washing by late fall and early spring rains. The same general farm practices are used on nearly all soil types. Fields are double disked and harrowed. Most of the corn is planted in checkrows, from May 1 to May 15, the date of planting depending on seasonal conditions. As soon as the corn comes up, the land is harrowed. About three cultivations with a rotary hoe or corn cultivator are given the crop which is laid by between the 10th and 20th of July. Corn picking begins in late October. Formerly practically all the corn was picked by hand, but, owing to the scarcity of farm labor, much of it now is picked by machine. Ninety-two percent of the corn planted is husked or snapped for grain, and the remainder is cut for silage and fodder or is hogged off.

The yellow varieties of corn are most commonly grown. Locally developed strains of Reid Yellow Dent and Krug are the most popular open-pollinated varieties. The use of hybrid seed corn is increasing.

Oats are second in importance of the farm crops grown. In 1935, 37,561 acres were planted, and the average yield was 27.9 bushels an acre. Oats usually follow corn in the rotation. The corn stubble is double disked and dragged, after which the oats are broadcast (for the most part) and seeded at a rate ranging from 2 to 3 bushels an acre. The matured grain is cut in July with a binder, shocked, and threshed from the shock, after having been cured thoroughly. Most of the seed is grown locally and is selected from the bins of the previous year's crop. The seed used is locally grown strains of Green Russian, Iowar, Albion (Iowa 103), and Richland (Iowa 105). The

⁶ All statistics quoted in this section are from the Iowa Year Book of Agriculture for 1935.

oats are fed largely on the farm where grown, to work animals, or are ground and fed to hogs and cattle.

Rye was grown on 4,193 acres in 1935, and the average acre yield was 11.8 bushels. Barley is grown on small acreages for use as a supplementary feed, and practically all of it is fed to hogs and calves. Barley and oats are sometimes sown together and used as a mixed feed.

Soybeans are being grown more extensively. They are used mostly for hay but are becoming important as a cash crop on some farms. Soybean hay was cut from 12,482 acres, and soybeans for beans were harvested from 1,411 acres. Land to be planted to soybeans should be chosen carefully. The beans should be grown on flat lands or in fields having little slope, as they have a tendency to loosen the soil to a depth of a few inches, which causes it to erode seriously with every summer and fall rain. The most severe sheet washing takes place in the fall after the crop has been removed. The entire surface soil sometimes has been removed in one season from thinly covered slopes.

Sorgo, millet, Sudan grass, and flax are other minor crops.

Winter wheat, an important cash crop, was grown on 8,505 acres. At one time, wheat was as important a crop as corn and was extensively produced over the entire county. A large proportion of the wheat is grown on the bottom lands along Des Moines and Skunk Rivers. Small fields, ranging from 3 to 10 acres in size, are scattered on the upland farms over the entire county. The average yield for 1935 was 15.3 bushels an acre. Only 228 acres of spring wheat were grown, and the average acre yield (8.5 bushels) was much lower than that of winter wheat. Winter wheat is better adapted to this section of the State, as it matures earlier and usually escapes the early hot summer winds which reduce yields materially. The wheat is drilled and usually follows corn in the rotation. Turkey Red is the predominating variety grown. Seed is saved and is planted the following year on most farms.

Tame hay occupied 34,539 acres and produced an average of 1.52 tons an acre. Approximately 40 percent of all the hay grown is clover and timothy. Clover and timothy generally are sown with small grain, as the latter furnishes shade and protection for the young plants. Clover is cut for hay the season following the seeding, when it reaches its maximum growth. The second year the crop is largely timothy. Some timothy is cut for seed. Alfalfa is increasing in popularity and was grown on 5,613 acres in 1935. The average yield was 2.26 tons an acre. Fields on which alfalfa is grown must be limed. All the dark-colored upland soils range from medium to strongly acid. Tests should be made of each field, and sufficient lime should be applied to neutralize the acidity. Inoculation is also essential. Soybeans are acid tolerant and are usually grown without previous liming of the land. Soybeans constituted 36 percent of all the tame hay grown in 1935.

There were 133,617 acres in pasture in 1935, of which 37.4 percent was plowable pasture and 15.7 percent woodland pasture. Native bluegrass is the chief pasture grass. It grows luxuriantly on the uplands and on the better drained bottom lands. On the upland slopes, where the surface soil is thin or absent, and the yellow clay is exposed, pasture grasses burn badly in prolonged dry weather.

Unfortunately, little attention has been given to improvement of the pastures, many of which need reseeding and care. Livestock are turned into the pasture early in March and left until late in the fall. Fields of small-grain stubble and cornfields, after the corn is picked, carry the livestock well into winter with little supplementary feed.

Crop rotation is practiced to some extent on all farms but is inadequate in a majority of instances. The common rotation is as follows: Corn, corn, oats or corn, and oats, with an occasional seeding to timothy and clover. Although the flat to gently undulating upland and the heavy bottom-land soils can stand more cultivation than other soils in the county, they cannot be cropped continuously without harmful results and an appreciable lowering of crop yields. On many slopes, where the soil has been poorly managed, light-colored infertile subsoils have been exposed through the removal of the rich dark-colored surface soils. Contour plowing and cultivating, suitable crop rotation, strip cropping, seeding waterways, and other soil conservation practices are being demonstrated in a watershed area south of Knoxville, by the Department of Agriculture. These practices are particularly useful on Tama silt loam, Muscatine silt loam, slope phase, Shelby silt loam, and the light-colored upland soils on all slopes with a gradient in excess of 3 percent. Too much emphasis can scarcely be placed on the practice of seeding systematically with red clover or other legumes. Where the land is badly run down, a 3-year rotation should be practiced, clover being seeded with the small grain following only 1 year's cropping to corn. The entire clover crop should be turned under in the first rotation and the second crop in each succeeding rotation. Alfalfa grown in rotation is left 4 or 5 years. A 4-year rotation is recommended only on flat or undulating uplands or on the dark-colored bottom lands which produce good yields normally. The 4-year rotation will tend to maintain fertility, but it is not adequate for building up the soil where yields are comparatively low and the soil has been run down through poor cropping practices.

Soybeans in the rotation should be grown on level areas if possible. Sloping fields may erode badly after the crop is removed because this crop loosens the upper 2 or 3 inches of soil and forms an incoherent finely granular or dustlike mulch which washes severely. In extreme instances the entire surface soil has been removed, leaving the unproductive clay subsoil exposed.

Considerable native forest grows over the county on slopes along Des Moines and Skunk Rivers and the larger creeks. Timber has been cut indiscriminately and slopes cleared where the land was unsuited for cultivation. As a result sheet and gully erosion have exposed reddish-brown, yellowish-brown, and gray clay subsoils in many fields, on which nothing but a few weeds and grasses will grow. The light-colored soils—Lindley silt loam, Clinton silt loam, and Weller silt loam—developed under forest cover are best adapted to the growing of trees, with the exception of the undulating or gently rolling ridge tops and divides which will produce good small-grain and hay crops. Selective cutting of the original timber from these soils might have been more profitable in the long run than clearing and cultivating the land. Considerable timber is still being cut. It is used for mine props, posts, and rough lumber for building purposes on the farm.

Experiments are being conducted by the Iowa Agricultural Experiment Station in neighboring counties on soils similar to those which predominate in Marion County. The experimental plots are one-tenth of an acre in size. A definite rotation is used by the farmer cooperators, who plant and cultivate the crops on the plots along with his regular crops. The plots are established on typical soils. A careful record is made of yields and conditions throughout the season by a fieldman from the experiment station, who applies the lime and fertilizers and harvests the crop.

These experiments include tests of different fertilizers under both grain and livestock systems of farming. The older fields were laid out under both systems, but on the newer fields only a livestock system is used. The new fields have 9 plots including 3 check plots and the older fields, 13 plots including 3 check plots. Under the livestock system, barnyard manure is applied at the rate of 8 tons an acre, once in a 4-year rotation, together with crop residues plowed under. Limestone is applied in sufficient quantity to neutralize the acidity of the soil. Tests are made of the lime requirement once in the rotation, and additional lime is applied every fourth year if needed. Under the grain system of farming, organic matter is supplied by plowing under crop residues and, in some instances, the second crop of clover but no manure. Generally, the first crop of clover is used for hay and the second crop is left for seed or plowed under.

Rock phosphate and superphosphate are applied in both the grain and livestock systems. Rock phosphate was applied at the rate of 1 ton an acre prior to 1925, once in a 4-year rotation. During the years 1925 to 1932, inclusive, 1,000 pounds of rock phosphate were used in the 4-year rotation, and since then only 500 pounds have been used. Superphosphate (16-percent) was applied at the annual rate of 200 pounds an acre at first. In 1923 the application was reduced to 150 pounds and was made 3 years out of 4, being omitted in the year in which a legume crop was produced; and since 1929, an equivalent amount (120 pounds) of 20-percent superphosphate an acre has been used.

Complete commercial fertilizer, 2-8-2,⁷ was used at the rate of 300 pounds an acre annually and disked in, but this was changed in 1923 to a 2-12-2 mixture, the equivalent of 150 pounds of 16-percent superphosphate, which was applied at the rate of 200 pounds an acre. Since 1929, a 2-16-6 mixture has been used at the rate of 200 pounds an acre. Potash in the form of muriate of potash is applied at the rate of 50 pounds an acre, 3 years out of 4, in a 4-year rotation.

The results of experiments on the use of fertilizers on Clinton silt loam, Grundy silt loam, and Tama silt loam are of interest to farmers in Marion County, inasmuch as these soils together constitute 39.3 percent of the total area. The Tama and Grundy soils represent two of the best dark-colored upland soils in the county. The Clinton soil is the most extensively developed and farmed of the light-colored soils.

Table 7 gives the results of limestone and fertilizer treatments on corn, oats, winter wheat, and clover on Grundy silt loam, averaged from 12 individual experiment fields in Jefferson, Henry, Mahaska, Lee, Louisa, Ringgold, Van Buren, Wapello, and Wayne Counties. Both grain and livestock systems of farming are represented.

⁷ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

TABLE 7.—Average acre yields¹ of crops and increases due to fertilizer treatment on Iowa experiment fields² on Grundy silt loam

Treatment	Corn		Oats		Timothy and clover hay, alone or mixed		Winter wheat	
	Average yield	Increase from treatment	Average yield	Increase from treatment	Average yield	Increase from treatment	Average yield	Increase from treatment
13-plot series:	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Tons</i>	<i>Tons</i>	<i>Bushels</i>	<i>Bushels</i>
Check ³	55.9	-----	44.7	-----	1.23	-----	22.2	-----
Manure.....	60.0	4.1	48.3	3.6	1.32	0.09	24.6	2.4
Manure+limestone.....	67.5	11.6	51.4	6.7	1.66	.43	28.0	5.8
Manure+limestone+rock phosphate.....	71.5	15.6	58.1	13.4	1.89	.66	32.7	10.5
Manure+limestone+superphosphate.....	72.2	16.3	64.5	19.8	2.21	.98	34.8	12.6
Manure+limestone+complete commercial fertilizer.....	71.0	15.1	61.0	16.3	2.26	1.03	34.5	12.3
Limestone.....	62.2	6.3	52.4	7.7	1.82	.59	28.6	6.4
Limestone+rock phosphate.....	64.1	8.2	55.8	11.1	2.01	.78	29.4	7.2
Limestone+superphosphate.....	64.0	8.1	56.6	11.9	2.04	.81	30.3	8.1
Limestone+complete commercial fertilizer.....	64.5	8.6	57.2	12.5	2.04	.81	33.3	11.1
9-plot series:								
Check ³	51.3	-----	42.6	-----	1.25	-----	21.5	-----
Manure.....	55.1	3.8	47.6	5.0	1.60	.35	26.2	4.7
Manure+limestone.....	59.6	8.3	50.8	8.2	1.68	.43	27.0	5.5
Manure+limestone+rock phosphate.....	59.7	8.4	50.1	7.5	1.92	.67	31.7	10.2
Manure+limestone+superphosphate.....	61.4	10.1	51.0	8.4	1.98	.73	32.3	10.8
Manure+limestone+superphosphate+muriate of potash.....	63.5	12.2	49.8	7.2	2.19	.94	33.7	12.2
Manure+limestone+complete commercial fertilizer.....	62.6	11.3	54.1	11.5	2.03	.78	31.1	9.6

¹ 13-plot series: Corn yields averaged from 41 crops on 6 fields, oat yields from 21 crops on 6 fields, hay yields from 16 crops on 5 fields, and winter wheat yields from 6 crops on 3 fields. 9-plot series: Corn yields averaged from 24 crops on 6 fields, oat yields from 9 crops on 6 fields, hay yields from 8 crops on 5 fields, and winter wheat yields from 6 crops on 3 fields. (Table includes 1935 data.)

² 13-plot series includes Farson fields, series 2 and 4; Agency field, series 1; West Point fields, No. 1, series 1; and Mount Pleasant fields, series 100 and 200. 9-plot series includes Wapello field, series 1; Cedar field, series 1; Corydon field, series 1; Libertyville field, series 1; Milton field, series 1; and Denmark field, series 3.

³ The yields given for the checks are the average of the yields on all check plots on all fields.

The value and effectiveness of lime, manure, and either rock phosphate or superphosphate are clearly indicated in the results given in table 7. Lime showed the greatest economic return under both livestock and grain systems of farming. Marked increases were shown in the yields of corn, oats, barley, and winter wheat, with manure and lime. The increases due to phosphate, both rock phosphate and superphosphate, are pronounced in the 13-plot series, but only slight in the 9-plot series. Superphosphate seemed to be slightly more effective than raw rock phosphate. Potash used in addition to lime, superphosphate, and manure gave no significant increases in yield, and complete commercial fertilizer, when used with manure and lime, was not consistently superior to superphosphate. Superphosphate and rock phosphate seemed to be more effective in the livestock system than in the grain system of farming.

The results of experiments on the Agency field in Wapello County are given in table 8. These experiments cover a period of 18 years and show the effects of manure, lime, and fertilizers under both livestock and grain systems of farming. The results are, in general, similar to those reported in table 7.

TABLE 8.—Acre yields in field experiments ¹ on Grundy silt loam in Wapello County, Iowa

Plot No.	Treatment						Corn		Oats, 1925	Winter wheat, 1926 ²	Timothy and clover, 1927	Corn		Oats, 1930	Winter wheat, 1931	Red clover, 1932	Corn		Oats, 1935
		Corn, 1918	Oats, 1919	Winter wheat, 1920	Timothy and clover, 1921	Timothy, 1922	1923	1924 ³				1928	1929				1933	1934 ³	
		Bu.	Bu.	Bu.	Tons	Tons			Bu.	Bu.	Bu.			Bu.	Tons	Bu.			Bu.
1	Check.....	63.5	44.9	22.7	1.92	2.00	72.7	46.4	66.2	21.7	1.28	83.3	66.8	52.3	20.4	2.24	54.5	-----	48.8
2	Manure.....	64.5	62.2	31.5	2.09	2.20	71.8	51.9	70.8	19.0	1.96	89.4	72.7	63.7	28.3	2.05	62.1	-----	45.4
3	Manure+limestone.....	66.8	58.3	36.7	2.20	2.25	79.2	52.2	73.8	21.8	2.28	100.5	72.6	64.8	26.4	2.31	71.8	-----	54.5
4	Manure+limestone+rock phosphate.....	68.8	63.6	38.7	2.52	2.30	86.8	54.0	80.6	35.3	2.14	105.4	83.4	80.8	39.3	2.35	75.8	-----	54.5
5	Manure+limestone+superphosphate.....	70.0	66.6	40.0	2.39	2.80	85.4	60.2	77.9	38.9	2.05	97.8	78.2	83.3	38.2	2.38	72.9	-----	63.5
6	Manure+limestone+complete commercial fertilizer.....	66.0	65.6	34.7	2.52	2.50	83.0	55.4	77.3	30.7	2.47	101.0	85.1	68.6	43.6	2.50	77.6	-----	51.0
7, 8	Check.....	58.9	51.8	31.4	1.82	2.25	68.0	43.5	67.1	16.7	1.29	75.9	65.6	53.6	21.1	1.87	58.3	-----	42.2
9	Limestone.....	61.3	59.5	43.8	2.02	2.40	71.3	50.7	72.1	18.6	1.69	83.5	73.2	59.2	28.3	2.14	65.1	-----	48.8
10	Limestone+rock phosphate.....	61.8	61.2	36.4	2.33	2.65	73.1	54.9	75.9	26.0	2.14	96.6	77.5	70.3	30.9	2.32	67.5	-----	57.9
11	Limestone+superphosphate.....	63.5	61.2	36.3	2.19	2.75	80.7	55.5	74.6	-----	2.26	93.4	69.0	72.4	36.0	2.29	68.6	-----	54.5
12	Limestone+complete commercial fertilizer.....	62.5	63.6	35.6	2.17	2.65	70.4	54.4	78.4	-----	2.14	93.6	77.3	85.5	38.5	2.35	70.7	-----	60.1
13	Check.....	52.5	52.0	22.8	1.56	2.40	63.9	42.7	58.5	-----	.91	67.0	56.5	55.5	28.7	1.36	60.1	-----	49.9

¹ Agency field, series 1, in NE¼NW¼SE¼ sec. 30, R. 12 W., T. 72 N.

² Wet weather prevented seeding of plots 11, 12, and 13.

³ Corn poor due to drought; cut for fodder.

Table 9 shows the average crop yields and increases due to fertilizer treatments on 9 experiment fields on Tama silt loam, located in Grundy, Jasper, Madison, Adair, Benton, Marshall, and Cedar Counties. The results represent only the livestock system of farming.

TABLE 9.—Average acre yields¹ of crops and increases due to fertilizer treatment on Iowa experiment fields² on Tama silt loam

Treatment	Corn		Oats		Timothy and clover hay, alone or mixed	
	Average yield	Increase from treatment	Average yield	Increase from treatment	Average yield	Increase from treatment
	Bushels	Bushels	Bushels	Bushels	Tons	Tons
Check ³	58.5		52.7		1.59	
Manure.....	63.2	4.7	57.7	5.0	1.80	0.21
Manure+limestone.....	64.3	5.8	61.3	8.6	1.89	.30
Manure+limestone+rock phosphate.....	65.0	6.5	65.2	12.5	2.03	.44
Manure+limestone+superphosphate.....	65.5	7.0	67.6	14.9	2.12	.53
Manure+limestone+superphosphate+muriate of potash.....	65.0	6.5	67.1	14.4	2.05	.46
Manure+limestone+complete commercial fertilizer.....	64.7	6.2	68.8	16.1	2.01	.42

¹ Corn yields averaged from 41 crops on 9 fields, oat yields from 16 crops on 8 fields, and hay yields from 10 crops on 7 fields (includes 1936 data).

² Grundy Center field, series 1; Newton field, series 1; Winterset field, series 1; Greenfield fields, series 1 and 2; Keystone field, series 1; Le Grand field, series 1; West Branch field, series 1; and Van Horn field, series 1.

³ The yields given for the checks are the average of the yields on all the check plots on all fields.

These results emphasize the value of manure on this soil. Ground limestone, when used in addition to manure, gave slight increases in yield. Superphosphate, used with manure and lime, gave better returns than rock phosphate similarly used. The use of potash with manure, limestone, and superphosphate gave no increase in yields of crops, and complete commercial fertilizer showed no greater increase than did superphosphate when used with manure and limestone. Careful field tests should be made with potash or mixed commercial fertilizer, in order to determine the economic value of their use. Applications of lime, manure, and phosphate seem to give the greatest economic returns on Tama silt loam.

The results of fertilizer applications on an individual experiment field on Tama silt loam in Madison County, the second county to the west from Marion County are given in table 10. The results are comparable to the average results on nine individual fields located on Tama silt loam shown in table 9.

TABLE 10.—*Acre yields in field experiment ¹ on Tama silt loam in Madison County, Iowa*

Plot No.	Treatment	Corn		Oats, 1924	Clover, 1925	Corn			Oats, 1929	Timothy and clover, 1930	Corn		Oats, 1933 ⁴	Red clover, 1934 ⁵
		1922 ²	1923			1926 ³	1927	1928			1931	1932		
		<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Tons</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Tons</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Bushels</i>	<i>Tons</i>
1	Check.....	77.1	43.9	54.8	1.50	56.8	55.0	60.5	61.3	1.85	55.9	74.7	22.1	-----
2	Manure.....	77.2	46.6	59.2	1.58	63.5	57.6	59.5	59.0	2.11	53.4	77.8	20.4	-----
3	Manure+limestone.....	76.1	47.2	67.1	1.60	56.8	54.8	62.4	65.9	2.03	56.4	77.7	24.1	-----
4	Manure+limestone+rock phosphate.....	76.5	50.4	71.6	1.76	59.7	61.0	69.1	64.6	2.26	55.3	80.1	23.0	-----
5	Check.....	72.9	45.1	55.9	1.54	52.5	53.6	58.9	54.5	1.75	53.0	74.4	19.3	-----
6	Manure+limestone+superphosphate.....	79.7	49.8	67.5	1.61	53.0	57.9	64.8	58.1	2.45	56.3	80.8	27.2	-----
7	Manure+limestone+superphosphate+muriate of potash.....	81.0	50.9	65.5	1.63	55.0	60.0	62.9	67.0	2.33	55.7	82.5	25.5	-----
8	Manure+limestone+complete commercial fertilizer.....	72.1	52.0	68.2	1.55	51.5	51.1	63.5	68.1	2.20	54.7	80.9	26.1	-----
9	Check.....	72.7	43.9	52.6	1.54	46.4	47.8	63.7	56.8	1.84	51.8	75.5	20.0	-----

¹ Winterset field, series 1, in SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 23, T. 76 N., R. 28 W.

² Limestone not applied until 1923.

³ Unable to account for high yield on plot 2.

⁴ Hot dry weather in June and July seriously damaged oats.

⁵ Poor stand due to drought; field pastured; no results.

Results of acre yields and increases due to fertilizer treatment on Clinton silt loam on four experiment fields in Iowa counties are shown in table 11. The results represent only the livestock system of farming.

TABLE 11.—Average acre yields¹ of crops and increases due to fertilizer treatment on Iowa experiment fields² on Clinton silt loam

Treatment	Corn		Oats		Timothy and clover hay, alone or mixed	
	Average yield	Increase from treatment	Average yield	Increase from treatment	Average yield	Increase from treatment
	Bushels	Bushels	Bushels	Bushels	Tons	Tons
Check ³	42.3		34.9		0.97	
Manure.....	48.9	6.6	44.1	9.2	1.21	0.24
Manure+limestone.....	56.6	14.3	53.9	19.0	1.64	.67
Manure+limestone+rock phosphate.....	58.0	15.7	56.7	21.8	1.67	.70
Manure+limestone+superphosphate.....	58.9	16.6	55.5	20.6	1.86	.89
Manure+limestone+superphosphate+muriate of potash.....	61.6	19.3	61.1	26.2	1.93	.96
Manure+limestone+complete commercial fertilizer.....	59.2	16.9	58.7	23.8	1.73	.76

¹ Corn yields averaged from 14 crops on 4 fields, oat yields from 9 crops on 4 fields, and hay yields from 7 crops on 3 fields (includes 1935 data).

² Burlington field, series 1; Keosauqua field, series 1; Julien field, series 1; Lockridge field No. 2, series 1.

³ The yields given for the checks are the average of the yields on all check plots on all fields.

The use of manure alone shows a big increase in yield on Clinton silt loam which normally is low in organic-matter content. Where lime was applied with manure, large additional increases in the yields of corn, oats, and hay were obtained. Rock phosphate and superphosphate, when used with lime and manure, gave only slight increases in yields of corn, oats, and hay. Muriate of potash and complete fertilizer, when used in addition to manure and lime, also showed only slight increases in yield.

Experiments on Muscatine silt loam indicate that this soil will respond to treatments of manure, lime, and phosphate fertilizers.⁴

The results of these experiments, as well as many others conducted on various soils throughout Iowa, emphasize the importance of soil treatments in obtaining larger crop yields and in keeping the land permanently productive.

Manuring and green manuring are important practices in keeping up the supply of organic matter in the soils of Marion County, as well as furnishing additional plant nutrients. Liming also is important, especially where legume crops are grown.

Rock phosphate or superphosphate may be used to advantage on most crops. In order to determine which may be employed most profitably, farmers should test both fertilizers on their individual farms. Muriate of potash may be used with value on some soils for certain crops, but tests should be conducted on small areas before applying this amendment to an extensive area.

⁴ STEVENSON, W. H., BROWN, P. E., FORMAN, L. W., MELDRUM, H. R., ENGLEHORN, A. J., and BENNETT, R. E. FIELD EXPERIMENTS WITH FERTILIZERS ON SOME IOWA SOILS. Iowa Agr. Expt. Sta. Bull. 269, pp. 165-202, illus. 1930.

Complete commercial fertilizers may be applied profitably to some soils, but experiments indicate that under average conditions a straight phosphate fertilizer gives as good results and greater profits. Comparison tests with phosphates are desirable.

Weller silt loam, Lindley silt loam, Clinton silt loam, shallow phase, and Shelby silt loam have rolling to hilly relief, have moderately heavy to extremely heavy subsoils, and are highly erodible. The more rolling areas of these soils should be left in permanent pasture or forest, and only the gently sloping areas should be cultivated. Careful cultivation and cropping and the use of the best practices for control of erosion are necessary in order to maintain fertility of these soils. Contour plowing and cultivating and seeding the small surface ditches are recommended in rolling areas. A 3-year rotation should be used where crop yields have decreased and the soils need building up. A clean-cultivated crop should be grown only once in every 4 years on the more erodible rolling lands. Corn, small grain, and clover or clover and timothy make a satisfactory 3-year rotation. When used as a 4-year rotation, the field is left in hay the fourth year.

On farms where the land is flat or gently rolling and the fertility of the soil has been maintained, especially on those which include the darker Prairie soils, a 4-year rotation of corn, corn, small grain, and clover will tend to maintain productivity.

The heavy dark-colored soils of the bottom lands and terraces—Wabash silty clay loam, Cass silty clay loam, and Bremer silty clay loam—which have poor natural drainage because of the heavy subsoils and flat relief, would be greatly benefited by sweetclover grown in the rotation. Internal drainage and tilth would be greatly improved by the deep penetration of the roots and the plowing under of a coarse vegetal growth.

Many of the upland soils on slopes with a gradient in excess of 8 percent, that are now in cultivation, should be retired to permanent pasture. Unfortunately much of this land must be farmed because of the lack of more level land on the individual farm.

Approximately 40 percent of all land in this county is in pasture. Brush, weeds, and scattered trees occupy many of the hillside pastures. Such areas, which are adapted to pasture, should be cleared and seeded to pasture grasses. Reseeding old pastures with mixtures of red clover, sweetclover, alsike clover, and timothy will greatly improve their value for grazing. Inoculated legumes are important in a pasture, as they have the ability to supply available nitrogen to the grasses. Success with legumes on many soils depends on the use of lime and phosphate fertilizers. Reseeding should be done in early spring and the land disked. On some of the lighter soils and on soils low in organic matter, eroded, and run-down, lespedeza is being tried for pasture, because of its ability to withstand drought. It is tolerant of acidity and grows more successfully than clover on run-down land. An early maturing variety is recommended, as otherwise it may not reseed itself. Lespedeza seems to grow better than any other legume or grass on areas in which the unproductive subsoil is exposed. In places where some surface soil remains, even though the layer be thin, a mixture of lespedeza, timothy, alsike clover, and Canada bluegrass has been used successfully. In

places where the soil is sweet, sweetclover may be used in the mixture. Practices recommended for the control of erosion in the soils of Marion County include improved systems of rotation, contour tillage, contour strip cropping, retirement of eroded areas unfit for cultivation to pasture, improvement of the pastures, contour furrowing, liming, and the use of legumes as green manure.⁹

MORPHOLOGY AND GENESIS OF SOILS

The principal sources of the soil-forming materials in Marion County are loess, glacial drift, and alluvium. Sandstone strata of the bedrock contribute a comparatively small quantity of sandy material. The loess deposits of Peorian age occupy the high parts of the upland, the preglacial valleys, and, in some places, where they have washed down over the drift, the slopes of glacial valleys. The thickness of the loess ranges from a few inches to 17 feet.¹⁰ Drift of the Kansan stage originally covered the entire county, forming an almost level plain which, even before the deposit of the loess, had suffered some erosion. The loess then covered the uneroded upland and the valleys existing at that time. Since deposition of the loess, streams have cut channels partly and, in places, entirely through both loess and drift. This explains the exposure, on the hillsides throughout the county, of bands of drift between the loess upland and the alluvium on the bottoms. The exposures of drift are shown on the map as areas of the Shelby and Lindley soils. Below the drift, ledges and cliffs border the bottoms, but they are so narrow that they have formed no soil areas of any importance. In three areas, however, sandy materials from sandstone strata have blown over the upland and have been incorporated with the surface soils. These areas are indicated on the map as Tama fine sandy loam.

Marion County is characterized by an intricate drainage system which has greatly influenced the soil-forming processes. The larger streams, together with their secondary systems, have cut deeply into the uplands, and stream cutting is so thorough that nearly every square mile is supplied with drainage outlets.

In general, the dark-colored soils of the upland were formed under the influence of grass vegetation on smooth areas with either adequate or poor drainage of both surface and subsoil layers. These dark-colored soils of the upland are called Prairie soils. The light-colored soils of the upland have developed under a forest growth on well-drained or excessively drained areas. The silty texture of the surface soil predominates over the entire county except on the slopes of the deeply eroded valleys where the glacial till lies near the surface and affects the texture by increasing the proportion of sand.

The soils of the nearly level divides have restricted surface drainage, restricted internal drainage, or both. The soil profile, therefore, cannot be considered as having developed under normal conditions. The soils of the level prairie have dark-colored surface soils, owing to the high content of organic matter which has accumulated

⁹ Additional information on soil management, soil erosion, and the results of field experiments with fertilizers is given in Iowa Agricultural Experiment Station Bulletins 269 and 280 and Special Reports 2 and 3; recommendations for pasture mixtures are given in Iowa Station Bulletin 331.

¹⁰ MILLER, B. L. GEOLOGY OF MARION COUNTY. Iowa Geol. Survey, v. 11, pp. 127-197. 1901.

and become an integral part of the upper layers through the decay of the prairie-grass roots. Drainage conditions greatly influenced the accumulation of this organic material, and the poorly drained level areas have thicker dark layers. The dark color of the A horizon reaches, in places, a depth of 16 inches, and dark organic streaks penetrate as deep as 40 inches into the lower horizons. The B horizon is olive-drab heavy clay loam or clay, stained with iron. Below this, the material becomes lighter textured, gray is the basic color, and streaks and stains from iron oxide are less numerous. Soils with this profile are classed in the Grundy series.

Following is a description of a profile of Grundy silt loam as observed in a pit along the State highway in sec. 26, Bluff Creek Township, in Monroe County, a few miles south of this county. This profile is representative of Grundy silt loam in Marion County.

1. 0 to 1½ inches, material consisting mainly of grass roots in all stages of decomposition, from the fresh plant roots to finely divided humus. The mineral content is dark grayish brown and silty. All the soil particles are small firm granules which, when crushed, are lighter colored than when unbroken.
2. 1½ to 12 inches, dark grayish-brown friable silt loam, the upper 2 inches of which are faintly laminated and the rest distinctly granular. All the soil granules are slightly larger than those of the grass-root layer above. They range from one-sixteenth to one-eighth inch in diameter. Grass roots penetrate the entire layer and cling tightly to the soil granules when the mass is shaken. The material in this layer is thoroughly worked by worms. The gray color imparted to the soil mass occurs as a thin coating around the granules and disappears when they are crushed. The soil is almost black when moist.
3. 12 to 18 inches, material which is slightly heavier and lighter colored than that in the layer above. It consists of a mass of rounded granules larger than those in either of the overlying layers. The undisturbed mass is dark grayish brown, but the crushed material is brown. The gray coating around some of the granules is more pronounced in this layer than it is in the layer above. A few grass roots penetrate the entire layer, clinging firmly to many granules when pulled from the mass. A few faint iron stains are present at the base of the layer.
4. 18 to 26 inches, a transitional layer of light silty clay loam which is yellowish brown when crushed. The entire mass consists of firm coarse granules that appear to be dark brown on the outside and yellowish brown within. Iron staining increases with depth.
5. 26 to 29 inches, silty clay, the basic color of which is drab, and in which mottlings of gray, brown, and yellowish brown are numerous. The structure is prismatic, and, on drying, the soil material breaks out in large blocks. The cleavage joints between the soil prisms are filled with what appears to be a colloidal substance that is greasy but very sticky. Some dark organic material has sifted downward along cleavage planes or cracks, formed during droughty periods. Iron stains are very numerous, but no hard concretions have formed.
6. 29 to 40 inches, silty clay loam, the basic color of which is dark gray or slate gray and in which there are mottlings of yellowish brown and other colors, together with iron stains. The material has no definite structure. A few hard iron concretions are present.

Muscatine silt loam has developed under somewhat better drainage conditions than has Grundy silt loam. Its gentle slope provides a more rapid removal of surplus moisture in the upper layers than is characteristic of the Grundy soil, but, apparently, drainage is continually or intermittently deficient in the lower part of the subsoil. The surface soil is dark-brown or almost black silt loam, the properties of which are similar to those of the surface soil of Tama silt loam. The upper subsoil layer is brown friable silt loam or silty

clay loam, and the lower subsoil layer is yellowish-brown silty clay mottled with gray and rust brown.

Tama silt loam has developed under conditions of good drainage and good aeration. The relief ranges from gently to sharply rolling. The surface soil is dark grayish-brown silt loam, and it is underlain by yellowish-brown silt loam which is mellow and friable at all depths.

The soils of these three series—Grundy, Muscatine, and Tama—represent the gradations in color, texture, and other characteristics produced in the same parent material as a result of differences in the content of soil moisture.

Following is a description of a typical profile of Tama silt loam as it occurs in Marion County:

1. 0 to 2 inches, very dark grayish-brown silt loam filled with a dense mat of interlaced grass roots. When wet, the surface layer is black, but, when dry, it is very dark grayish brown.
2. 2 to 14 inches, dark grayish-brown granular friable silt loam which breaks into small aggregates from one-sixteenth to one-eighth inch in diameter. This layer is uniformly darkened by the infiltration of organic matter.
3. 15 to 22 inches, a transitional layer of brown granular heavy but friable silty clay loam which breaks into aggregates one-fourth inch or less in diameter. When crushed between the fingers, the soil is light brown. The material is colored with infiltrations of organic matter, which are darkest around old soil cracks and around worm, root, and insect holes.
4. 22 to 34 inches, yellowish-brown heavy silty clay loam, highly oxidized and uniform in color. A few faint organic discolorations occur in root channels and in insect, worm, or animal burrows.
5. 34 to 50 inches, yellowish-brown silty clay loam, slightly lighter colored than the layer above. This layer has faint-gray or yellowish-gray mottlings. A few reddish-brown iron stains and concretions are present.
6. 50 to 68 inches, light-yellow friable silty clay loam mottled faintly with gray, yellowish brown, and brown. There are many rust-brown and a few black iron stains.

The Waukesha and O'Neill soils are dark-colored well-drained terrace soils which typically occupy a position below the upland slopes and above the first bottoms. The dark-colored Cass soils on the first bottoms have good intermittent drainage.

The light-colored soils are represented by the Clinton, Weller, Lindley, and Putnam soils on the uplands, Jackson silt loam on the terraces, and the Genesee soils on the first bottoms. With the exception of the Genesee soils and Clinton fine sandy loam, all the light-colored soils have heavy compact silty clay or clay subsoils. Putnam silt loam is intermediate between the Prairie and the forested soils. It has formed on a flat surface and has developed characteristically an intermediate gray silt layer. These light-colored soils were developed under forest cover which densely blanketed the slopes along the larger streams. The relief of the slopes is hilly and rough, for the most part, as the trees encroached only on eroded areas. Prairie grasses failed to grow under the heavy tree cover, and humus that may have been present originally was exhausted rapidly. The soils belong with the Gray-Brown Podzolic group. A light-colored typical forest soil was the result. The subsoils of the upland soils are derived either from loess or Kansan till.

Following is a description of a profile of Clinton silt loam which is representative of the group of light-colored soils:

1. 0 to 2 inches, grayish-brown silt loam containing much fine silt.
2. 2 to 12 inches, grayish-brown or yellowish-brown floury silt loam which breaks down into medium-sized aggregates with much interstitial silt.
3. 12 to 20 inches, yellowish-brown heavy silty clay loam which breaks down into small hard angular aggregates. When dry, a sprinkling or coating of gray appears on the aggregates.
4. 20 to 35 inches, yellowish-brown heavy silty clay. This is the layer of maximum compaction. When dry, the material in this layer breaks into columnar form and breaks further into small cubelike pieces, one-fourth inch or more in diameter. A gray sprinkling or coating partly or wholly covers the cubes along cleavage lines. The faces of the cubelike aggregates are shiny and smooth.
5. 35 to 48 inches, yellowish-brown friable silty clay loam which is lighter in texture than the material above. It breaks into irregular shaped clods. The columnar structure is not so pronounced in this layer. Some reddish-brown iron stains are present, largely in the lower part, and light-gray mottlings are scattered throughout.
6. 48 to 70 inches, gray silt loam or light silty clay loam, mottled with pale yellow. The material feels floury and smooth when rubbed between the fingers. Reddish-brown iron stains are abundant and extend in mycelial threads throughout the layer.

The reaction of Clinton silt loam varies widely. The surface soil ranges from neutral to slightly acid and the heavy compact subsoil from moderately to extremely acid.

Weller silt loam mapped in the southern and eastern parts of the county is similar to Clinton silt loam. It differs from the Clinton soil principally in having a tougher subsoil.

SUMMARY

Marion County is in south-central Iowa, two counties removed from the Missouri line. It comprises an area of 563 square miles, or 360,320 acres.

The county is part of a broad plateau which has been dissected thoroughly by Des Moines and Skunk Rivers and their tributaries. Remnants of the plateau remain as narrow flat tops of interstream divides, from one-half to 1 mile wide. The general slope of the county is eastward. Des Moines River, flowing southeastward through the north-central part carries most of the drainage waters. The extreme northeastern part is drained by Skunk River.

Elevations within the county range from 700 feet above sea level at the point where Des Moines River leaves the county to 1,008 feet in the southwestern part.

The early settlers came largely from the Eastern States. The extreme northeastern part was colonized by immigrants from the Netherlands. With the opening of mines in the nineties, southern Europeans were attracted to the mining communities. The population of the county in 1930 was 25,727. Knoxville, the county seat, had a population of 4,697 in that year.

Railroad facilities are adequate. Several paved and graveled highways traverse the county and provide ready access to markets. All the dirt roads are well graded and, for the most part, well maintained.

The climate is favorable for the production of all crops common to the general region. The mean annual temperature is 49.7° F., and the mean annual precipitation is 33.79 inches. The average length

of the frost-free season is 166 days, which is sufficient to mature all the crops commonly grown.

Agriculture is the leading occupation of the people. Corn, oats, and hay (the chief crops) occupy more than 90 percent of the total acreage in crops. The raising of cattle, hogs, and sheep is important, in the order named. Most of the grain and hay produced is fed to livestock. A considerable cash income is derived from the raising of poultry.

On the basis of soil characteristics and features which affect agriculture, the soils of Marion County are grouped as follows: (1) Dark-colored soils of the uplands and terraces, (2) light-colored soils of the uplands and terraces, and (3) soils of the bottom lands. The dark-colored soils are the most productive soils in the county and occupy the greater part of its total area.

Tama, Grundy, and Muscatine silt loams are the best agricultural soils of the uplands. Tama silt loam has good natural drainage, whereas the Muscatine and Grundy soils, occupying flat areas on the highest divides, require tiling before maximum production can be obtained. The Shelby soils occur on slopes and erode easily under clean cultivation. The surface soils of the Shelby soils are predominantly silt, but the subsoils are coarse glacial materials. The Waukesha and O'Neill soils, developed on terraces, are well drained, the latter excessively so, owing to a gravel or sand subsoil. Both produce good crops in normal seasons, but crops on the O'Neill soils are injured readily by drought. The Bremer soils occur on terraces where drainage is restricted. The Chariton soils are not so productive as most of the other dark-colored terrace soils, owing to restricted drainage. An intermediate white silt layer between the surface soil and subsoil characterizes this soil.

The relief of the light-colored soils, for the most part, is strongly rolling and hilly. The Clinton and Weller soils are developed from loess and occupy the upper slopes. Lindley silt loam is developed from deposits consisting of a 2- to 15-inch layer of loess over drift, and it occupies the lower slopes below the Clinton and Weller soils. Clinton silt loam, shallow phase, has a heavy intractable clay subsoil or is underlain by gray shale. All these soils were formed under a forest cover. Putnam silt loam is a transitional soil, as regards color, between the dark- and light-colored soils. The content of humus and the productivity of the light-colored soils are low compared with those features of the dark-colored soils.

Most of the soils of the bottom lands are dark colored, but they include small areas of light-colored soils of the Genesee series and riverwash, a loose incoherent infertile sand. Inherently, the Wabash soils are very fertile, but crops on these soils frequently are damaged by flood. The Cass soils are well to excessively drained, owing to the presence of a sand substratum at a depth of 18 to 20 inches, and they are less productive than the Wabash soils. The Genesee soils contain little organic matter but produce good yields of small grains. Riverwash is nonagricultural and is valuable only for the sand and gravel it contains, which are used in construction work.

This soil survey is a contribution from
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, *Chief*

SOIL SURVEY DIVISION

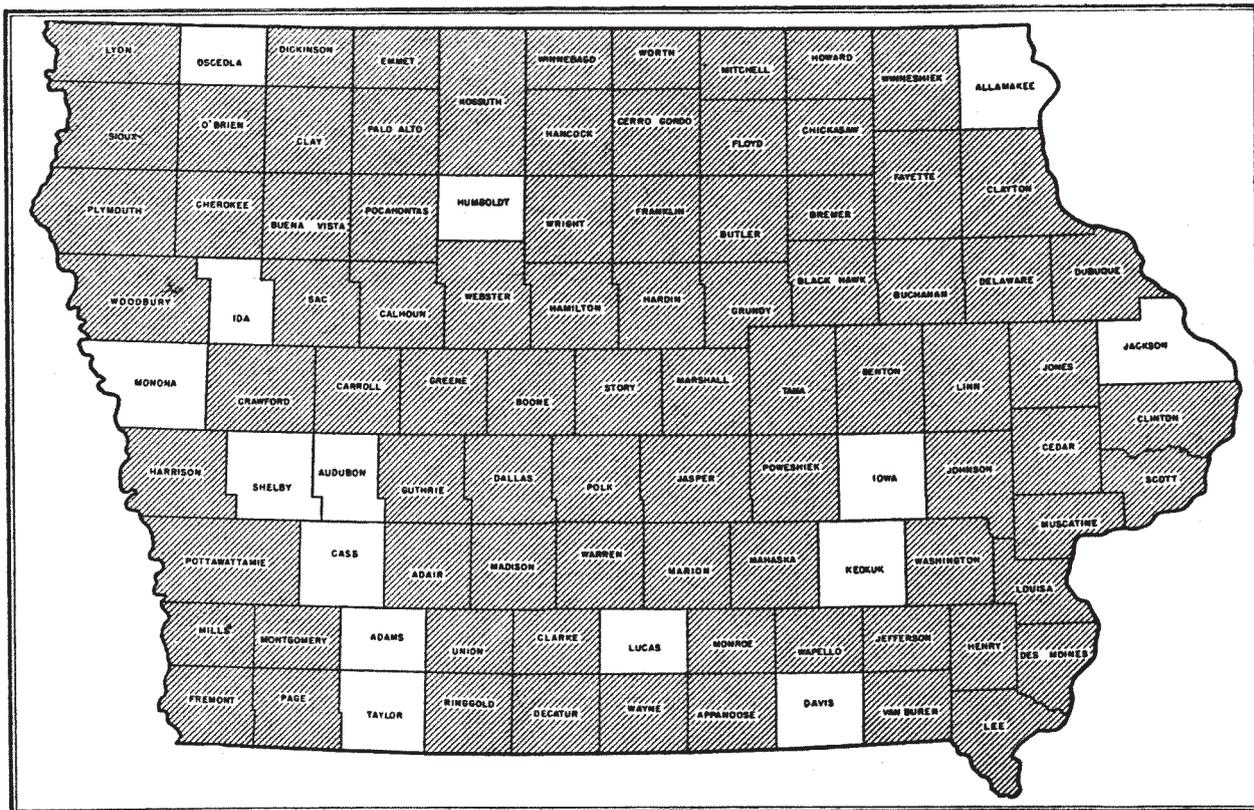
CHARLES E. KELLOGG, *Chief*
T. D. RICE, *Inspector, District 3*
J. W. MCKERICHER, *in Charge Map Drafting*

IOWA AGRICULTURAL EXPERIMENT STATION

R. E. BUCHANAN, *Director*
P. E. BROWN, *in Charge Soil Survey*

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Areas surveyed in Iowa shown by shading.

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