U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF SOILS—MILTON WHITNEY, Chief.

IN COOPERATION WITH THE IOWA AGRICULTURAL EXPERIMENT STATION, C. F. CURTISS, DIRECTOR; W. H. STEVENSON, IN CHARGE, SOIL SURVEY; P. E. BROWN, ASSOCIATE IN CHARGE.

SOIL SURVEY OF POLK COUNTY, IOWA.

BY

E. H. SMIES, OF THE U. S. DEPARTMENT OF AGRICULTURE, IN CHARGE, AND GEORGE E. CORSON AND CHARLES J. MEISTER, OF THE IOWA AGRICULTURAL EXPERIMENT STATION.

THOMAS D. RICE, INSPECTOR, NORTHERN DIVISION.

[Advance Sheets, Field Operations of the Bureau of Soils, 1918.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1921.

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U. S. DEPARTMENT OF AGRICULTURE,

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., November 24, 1920.

SIR: I have the honor to transmit herewith the manuscript report and map covering the soil survey of Polk County, Iowa, and to recommend that they be published as advance sheets of Field Operations of the Bureau of Soils, 1918, as authorized by law. This work was done in cooperation with the Iowa Agricultural Experiment Station, C. F. Curtiss, Director.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. E. T. MEREDITH,
Secretary of Agriculture.

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MAP.

Soil map, Polk County sheet, Iowa.

SOIL SURVEY OF POLK COUNTY, IOWA.

By E. H. SMIES, of the U. S. Department of Agriculture, In Charge, and GEORGE E. CORSON and CHARLES J. MEISTER, of the Iowa Agricultural Experiment Station.—Area Inspected by THOMAS D. RICE.

DESCRIPTION OF THE AREA.

Polk County, Iowa, is located in the south-central part of the State. The county seat, Des Moines, is the State capital and the largest city in the State. The county is nearly square and comprises 16 and a fraction land-survey townships, the fraction being in the southeast corner, where the Des Moines River forms the boundary between this and Warren County. The included area is 582 square miles, or 372,480 acres.

Broadly, the surface of Polk County is an even plain, with the surface drift-covered in the northern three-fourths of the county and silt-covered in the remainder. This prairie plain has been eroded somewhat, the relief being more pronounced in the immediate vicinity of the Des Moines River and in the region of the silt deposits, where the surface is prevailingly rolling. Most of the upland throughout the county, however, is flat or gently undulating, this topography extending in many places to within a mile of the present river flood plains. A few morainic knolls occur in the northwestern part of the area, but these are low and of small extent.

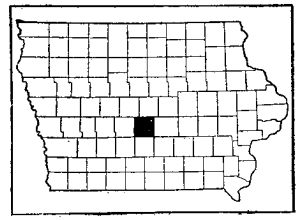

FIG. 1.—Sketch map showing location of the Polk County area, Iowa.

Hence there are two distinct topographic divisions in the county, one in the drift-covered region and one in the silt-covered region. The line separating the two runs approximately from Nobleton through Risingsun to the Des Moines River, and in the western part of the county from Valley Junction west to the county line. Except along the Des Moines River, the slopes to the larger streams in the drift-covered region are, in general, very gradual. Along the smaller drainageways there is ordinarily but little slope, and the streams occur as mere depressions, or swales. Most of the slopes along the Des Moines River are moderate, but in a few places they become rather abrupt. The divides are very broad and flat. In the silt-

covered region erosion has been much more active, and though the divides rise to an apparently level surface, they are quite narrow, and most of this region has well-rounded and moderately steep slopes.

The alluvial lands along the streams include old, high-lying terraces, now standing above the level of ordinary floods, and first bottoms, or present flood plains, practically all subject to frequent overflow. High terraces occur irregularly along the larger streams in all parts of the county. They are usually nearly flat and benchlike, though many of the older ones have become slightly undulating from comparatively recent erosion. First bottoms occur along the rivers and the lower courses of the larger creeks. They are composed of low-lying flood plains and slightly higher terraces, the latter subject to inundation only at rare intervals. Except where broken by old channels along the larger streams, the surface of the first-bottom land is in general nearly level.

The general elevation of most of the upland above sea level is between 975 and 1,010 feet. Mitchellville, in the eastern part of the county, has an altitude of 976 feet; Ankeny, near the center, 1,005; Sheldahl, in the northwestern part, 1,020; Grimes, in the western, 964; Orillia, in Warren County, just over the southwestern boundary line, 975; and Fort Des Moines, in the southern, 955. The prevailing slope is from the northwest to the southeast, and is slight. The elevation near the junction of the Des Moines and Raccoon Rivers is about 800 feet above sea level.

The county lies within the drainage basins of the Des Moines and Skunk Rivers, the former draining over four-fifths of the county. Its channel varies from 300 to 600 feet in width, and its moderately swift current is utilized for power purposes at Des Moines. Its valley is separated into two sharply contrasted portions lying respectively above and below the mouth of the Raccoon River. The upper valley is very recent, narrow, and rather steep-sided. The lower is broad, well matured, and has a well-developed flood plain. The alluvial plain lies from 120 to 140 feet below the general level of the adjacent upland, and varies in width from one-fourth to 1½ miles in the upper course and from 3 to 4 miles in the lower.

The principal tributary to the Des Moines River in the county is the Raccoon River, which heads near Storm Lake and enters the county near the southwest corner. Its valley is well developed. The channel varies in width from 100 to 200 feet, and the current is rather swift. Its flood plain is about a mile wide. The tributaries of this river from the south are small but evidently old. Walnut Creek, which flows into it from the north, has a small flood plain and is a more recent development. Beaver Creek flows through a broad preglacial terrace plain,[1] paralleling the Des Moines River

[1] See Geology of Polk County, by H. F. Bain.

to the south, and joining it just north of Des Moines. Its terrace plain averages about 2 miles in width, but the flood plain is rarely over one-fourth mile wide. Another important tributary to the Des Moines is the North River, which flows along the south county line, south of Avon Station. Its flood plain is rather narrow.

The Skunk River flows in a narrow channel and has a level flood plain averaging nearly 2 miles in width. Its valley slopes are very gradual and rise from 60 to 80 feet to the general level of the uplands from 1 to 2 miles inland. The river has one important tributary, Indian Creek, which parallels it in the northeastern corner of the county. Indian Creek is apparently fairly well matured, and has a flood plain averaging nearly a mile in width.

Drainage is best established in those sections that lie in close proximity to the Des Moines and Skunk Rivers, Indian and Beaver Creeks, and along the lower courses of Fourmile, Saylor, and Rock Creeks. Over much of the broad, gently undulating, drift-covered divide between the Skunk and Des Moines Rivers, i. e., the north-central part of the county, extending from Sheldahl to Altoona and Mitchellville, and in the region southeast of Kelsey and between Grimes and Walnut Creek, there is not enough surface relief for adequate drainage. These regions were largely in a marshy condition when the county was first settled, and are now traversed by numerous meandering sloughs. These sloughs are often connected by drainage ways that are barely perceptible in the generally level surface. They eventually empty into larger streams or into larger saucerlike depressions, where the water may stand until carried off through underground tile systems. Along the more abrupt slopes to the Des Moines River drainage is often excessive, but in the southern third of the county only a small part of the surface is excessively drained.

In the upland, wells are usually drilled, and permanent water is obtained at varying levels, though it is rarely necessary to go below 175 feet. On alluvial lands and in the silt-covered region sufficient water is often obtained in shallow dug wells.

Polk County was originally part of the Sac and Fox Indian Reservation, and was thrown open for settlement in 1842. Fort Des Moines, situated just south of the confluence of the Raccoon and Des Moines Rivers, was established in 1843. Beginning in 1844 settlers emigrated from Illinois, Indiana, Ohio, and even the New England States, and located along the timbered streams. By 1846, according to the State census, the population of the county was 1,301. In that year the county was organized. By 1850 the population had increased to 4,513, and since then has more than doubled in each decade until after 1900; and from this date it has steadily increased until in 1920 it totaled 154,029, an increase of 39.5 per cent over that of 1910.

A large percentage of the population of Polk County is of native birth. Of the foreign nationalities represented, the largest numbers come from Sweden, Germany, Italy, and England. There is a small settlement of Scandinavians in the vicinity of Sheldahl and of Germans near Alleman. A large number of Italians are located near the mines. In 1920 the urban population, comprising Des Moines and Valley Junction, amounted to 84.5 per cent of the total, while only 15.5 per cent was rural. With the exception of the immediate vicinity of Des Moines, the rural population is quite evenly distributed over the county. Des Moines, the State capital and the county seat, is located in the south-central part of the county and had a population of 126,468 in 1920. Valley Junction, the only other city in the county, is located adjacent to Des Moines. Its population was 3,631 in 1920. Of the more important towns, Mitchellville in the eastern part had a population of 752 in 1920; Fort Des Moines in the southern 1,020; Ankeny in the central, 648; and Altoona in the east-central, 502. Other important trading centers are Bondurant, Sheldahl, Grimes, Polk, Elkhart, Runnells, Adelphi, and Enterprise. All these towns have facilities for shipping grain and live stock. There is a canning factory at Altoona, one at Grimes, and one at Maxwell, just north of the northeast corner of the county. Des Moines has packing plants and two flour mills. The flour mill at Prairie City, 5 miles east of the county, furnishes a market for much of the grain in the southeastern section of the county.

Polk County is exceptionally well supplied with railroads, no farm being over 7 miles and very few over 6 miles from a station. Main or branch lines of the Chicago, Rock Island & Pacific Railroad, the Chicago Great Western Railroad, the Chicago, Milwaukee & St. Paul Railway, the Minneapolis & St. Louis Railroad, the Chicago, Burlington & Quincy Railway, the Wabash Railroad, and the Chicago & North Western Railroad extend to various parts of the county. In addition, three electric lines, hauling both passengers and freight, connect Des Moines with Colfax (in Jasper County), Fort Dodge (in Webster County), and Perry (in Dallas County). All the railroads in the county enter Des Moines.

The principal wagon roads are kept in good condition, but little attention is paid to the less important ones. Outside the cities of Des Moines and Valley Junction the roads are earth, with the exceptions of a graveled highway from Des Moines to Altoona and one from Des Moines to Alleman, and the paved highway from Des Moines to Camp Dodge. There is an abundance of good road gravel in the county and it is fairly well distributed, except in the northeast and southeast corners. The roads follow or run parallel to section lines, except along the rivers. All the stream crossings are bridged.

The rural free delivery mail routes and telephone lines reach every community in the county. In the rural districts there are 14 consolidated schools. Outside of the consolidated districts, schools are maintained at distances approximating 2 miles.

Des Moines furnishes an excellent local market for all farm products. However, transportation facilities to larger markets are plentiful. The small proportion of grain and live stock shipped out of the county goes mostly to Omaha and Chicago.

CLIMATE.

The climate of Polk County is characterized by a wide annual range in temperature. In general, the winters are cold, the springs cool, the summers hot, and the falls cool and rather pleasant. The climate is favorable for the production of corn and oats and usually for hay crops. An extreme temperature of 109° F. in July has been recorded by the Weather Bureau station at Des Moines, while the minimum, —30° F., occurred in January. The mean annual temperature is 49.3° F. Wheat is killed in extremely cold winters. Corn has been damaged by occasional hot winds on some of the shallower soils.

The annual rainfall averages 32.5 inches. Over 70 per cent of the precipitation occurs during the growing season, April to September, inclusive. The wettest months are May and June and the driest January and February. The wettest year on record (1881) has a rainfall of 56.81 inches, the driest (1901) 19.77 inches. Severe droughts are rare, and total crop failures are unknown. Some damage to leguminous crops occurs when a very cold winter is followed by a dry spring and early summer. Wind and hail occasionally cause some damage. Tornadoes are rare.

The average annual snowfall is 34.7 inches, and snow often remains on the ground throughout the greater part of the winter season.

The average growing season is about 171 days, which is sufficiently long for maturing the ordinary farm crops. The average date of the first killing frost in the fall is October 1 and of the last in the spring April 22. The latest recorded killing frost in the spring occurred May 9 and the earliest in the fall September 22. Crops are seldom damaged by early frosts. The grazing season extends from the last of April to the middle of November.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation for Polk County for 39 years, as recorded by the Weather Bureau station at Des Moines:

Normal monthly, seasonal, and annual temperature and precipitation at Des Moines.

[Elevation, 861 feet.]

Month.	Temperature.			Precipitation.			
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1881).	Snow, average depth.
	°F.	°F.	°F.	Inches.	Inches.	Inches.	Inches.
December	25.7	69	−20	1.31	0.20	1.85	7.9
January	20.4	64	−30	1.21	1.72	1.55	9.9
February	24.1	70	−26	1.08	.20	2.68	7.4
Winter	23.4	70	−30	3.60	2.12	6.08	25.2
March	35.7	88	−10	1.65	.33	1.78	6.1
April	50.6	92	11	2.98	1.13	3.36	1.0
May	61.6	96	26	4.45	3.26	3.82	T.
Spring	49.3	96	−10	9.19	4.72	8.96	7.1
June	70.4	102	37	4.96	3.11	15.79	.0
July	75.5	109	48	3.86	.86	5.57	.0
August	73.0	110	40	3.61	2.40	5.29	.0
Summer	73.0	110	37	12.43	6.37	26.65	.0
September	65.0	99	26	3.07	3.82	4.70	.0
October	52 5	91	14	2.68	.68	6.45	.2
November	36.8	79	−10	1.54	.53	3.97	2.2
Fall	51.4	99	−10	7.29	5.03	15.12	2.4
Year	49.3	110	−30	32.51	18.24	56.81	34.7

AGRICULTURE.

Polk County originally supported a heavy growth of prairie grass in the undulating and gently rolling sections and a luxuriant growth of slough grass on the bottoms and in the marshy areas on the uplands. A forest growth, consisting mainly of oaks, ash, elms, locust, wild cherry, and hackberry grew on the more rolling slopes and the better drained bottoms of the rivers and larger creeks.

The agriculture of the county dates back to 1844, when the first rural settlers located in Beaver and Allen Townships. During the two years following settlements were made in all the townships that had any forest growth. The pioneers, mainly from Illinois, Indiana, and Ohio, brought with them a small amount of live stock and grain seed. Corn was the principal crop, followed in importance by winter wheat, with some oats, rye, and barley. Flax, tobacco, potatoes, and sorghum were grown to a limited extent.

Wheat was the principal cash crop, the others being grown chiefly to supply home needs, although a market for grain and truck crops was always found at Fort Des Moines. Early transportation was by way of the Des Moines River.

In 1880 the main crops were corn, winter wheat, oats, rye, and flax, named in the order of their importance. Ten years later, owing to continuous cropping, also possibly to winterkilling, the acreage devoted to winter wheat had decreased nearly 92 per cent. In the same period the oat acreage more than doubled. Flax, rye, barley, and sorghum were grown to some extent.

Corn has always been the most important crop, and the yields have been maintained in latter years through the adoption of systems of manuring and crop rotation. Oats has been a crop of second importance since the eighties. The acreage devoted to winter wheat has been third in rank for over 30 years, but the area seeded varies considerably from year to year, owing chiefly to climatic conditions. After the most of the prairie sod had been broken flax growing practically ceased. A small amount of barley, rye, and sorghum has always been grown. Potatoes have been planted on a smaller scale since 1900.

The present agriculture of Polk County consists mainly of a combination of grain farming and stock raising. This system has proved the most profitable from the standpoint of keeping up the soil fertility and in utilizing the crops grown. Most of the grain produced in the county is fed at home. Corn and wheat are the principal cash crops. Truck farming and truck combined with fruit farming is quite important in the vicinity of Des Moines. Dairying and the feeding of beef cattle in conjunction with general farming have become popular in late years. The importation of live stock for feeding is followed mostly in the northeastern part of the county and in the vicinity of Grimes.

Corn is the leading grain crop in the county. In 1920, 103,679 acres were devoted to this crop, with a production of 4,425,105 bushels, an average yield of 42.7 bushels per acre. The acreage has remained about the same since 1880. Most of the corn is from home-grown seed and probably 70 per cent is of the Reid's Yellow Dent variety. Boone County White is the only other important variety grown. Polk County has more breeders of pure corn than any other county in the State.[2] Probably 65 per cent of the corn produced is fed to stock on the farm where grown. About 15 per cent goes to other feeders in the county, and 20 per cent is sold to local markets to be used in food industries locally or to be shipped to an outside market, usually Chicago. On the whole, the best average corn yields

[2] See Records of Farm Bureau Organization.

are produced upon the heavier upland soils of the county and the better drained heavy first-bottom soils that are protected from overflow.

In 1920 there were 42,232 acres in oats, with a production of 1,500,660 bushels, or an average yield of 35.5 bushels per acre. About 60 per cent of the oat crop is composed of Silver Mine and Albion (Iowa 103) varieties, in equal proportions. Kherson and Richland (Iowa 105) each compose 10 to 12 per cent, while Green Russian, White Russian, and miscellaneous varieties make up the remainder. Approximately 65 per cent of the oat crop is utilized on the farm for feeding work stock, small pigs, calves, and dairy cattle. The remainder is sold to local markets and utilized chiefly by home industries.

The third most important grain crop is wheat. It is a cash crop. Nearly 90 per cent of the wheat grown is of the winter varieties. In 1917 only 4,080 acres were planted to winter wheat, but much of the crop either winterkilled or was injured by the dry spring following. According to the annual reports of the Iowa Board of Agriculture the average acreage devoted to that crop during the five years preceding 1918 is about 21,000 acres, with an average yield of nearly 20 bushels per acre. Approximately 95 per cent is of the Turkey variety. Spring wheat was not very popular in this county until within the last six or seven years, but the results so far obtained point to an increase in acreage, especially in seasons following a cold, open winter. There were 2,235 acres in this crop in 1917, and the production was 50,882 bushels, an average of 22.7 bushels per acre. This is a slightly higher average than that reported for the last five-year period. The varieties most largely planted are the Marquis and Early Java. According to the 1920 census the total wheat acreage (including both winter and spring wheat) was 39,458 with a production of 708,516 bushels. Practically all the wheat is sold to local flour mills. Ordinarily wheat seems to do best on the silty upland and the second-bottom soils of the county.

According to the 1920 census hay and forage crops occupied 33,276 acres with a yield of 72,749 tons. Of this acreage tame or cultivated grasses occupied 19,722 acres, yielding 29,597 tons; wild hay 1,883 acres, yielding 2,672 tons; the remainder being used for small grains cut for hay, leguminous hay corps, and various forage crops. Slightly over 50 per cent of the tame hay is a mixture of red clover and timothy, though considerable areas of each are sowed alone. Alfalfa is increasing in importance, and it has recently been observed that alfalfa stands the severe open winters better than clover. The acreage planted to alfalfa in 1920 was 766 and the average yield was 2.7 tons per acre. Some millet and some Sudan grass are grown. Practically all the tame hay is fed on the farms.

Of the wild hay the larger proportion consists of slough grass, of which there are coarse and fine leaved varieties. Most of the slough-grass hay is sold by the producers. The coarser varieties are eventually utilized for packing merchandise and the finer for feeding stock. A small amount of prairie grass and some bluegrass are cut for hay and used locally for feeding. Most of the wild hay is produced on low-lying, poorly drained soils, such as the Wabash clay and the Bremer clay.

Another important crop grown in the county is sweet corn. In 1917, according to the annual reports of the Iowa Board of Agriculture, this crop occupied 1,877 acres, and the production amounted to 4,084 tons. The acreage of this crop has increased considerably since 1917 because of the establishment of the canning factory at Altoona. The principal varieties grown are Stowells Evergreen and Country Gentleman. Sweet corn yields, in normal years, from 2 to 5 tons per acre. The crop has become popular in the country around Altoona, Grimes, and Maxwell (in Story County). Considerable sweet corn is also grown for sale in the markets of Des Moines.

Of the less important crops, barley was produced on 134 acres in 1920 and rye on 895 acres. Sorghum and Sudan grass, grown each year on small acreages, are planted more extensively in years unfavorable for the production of clover and alfalfa.

Potatoes occupied 952 acres in 1919. The most important varieties are Early Ohio, Irish Cobbler, and Rural New Yorker. Potatoes usually do best on the newly cleared timbered soils. Sweet potatoes occupy a small acreage on the sandier soils. Other common vegetables are produced on the sandy and the silty soils near Des Moines. Watermelons and cantaloupes of good quality are grown on the sandier terrace and upland soils.

Many small orchards are found on farms scattered throughout the county, though fruit growing is best developed on the silty soils. The apple is the most important fruit. There are at present six commercial apple orchards in the county, ranging in size from 10 to 40 acres. Among the varieties largely planted are the Jonathan, Grimes, and Ben Davis, while the Winesap, Ralls, Blacktwig, Wealthy, and Dutchess are found in many orchards. The production of apples in 1919 amounted to 74,975 bushels. The best producing orchards are carefully cultivated, pruned, and sprayed. Next to the apple the cherry is the most important fruit, but there are no large commercial orchards. The United States census of 1920 reports that 1,374,676 pounds of grapes were gathered in the county in 1919. There are five commercial vineyards ranging from 1 to 7 acres in size. Practically all of the larger vineyards are located on the silty soils. Some difficulty is experienced from winterkilling of the vines. Strawberries, raspberries, and blackberries are grown to

some extent for sale and for home use. All the fruit produced in the county finds a ready market in Des Moines.

The raising of live stock is of great importance in Polk County. According to the census of 1920 there were 34,699 head of cattle on farms that year, 67,016 hogs, 15,555 horses, 1,227 mules, and 7,351 sheep.

There are many purebred herds of hogs in the county. The most prominent breeds are the Poland-China, Duroc-Jersey, and Chester White. In recent years more Hampshires have been raised than formerly. Some hogs are shipped into the county annually for fattening, the largest numbers being fed in years of large corn production. Hog fattening is said to be most profitable in lots where cattle are also being fattened. The Des Moines market takes practically all the hogs sold from the farms in the county.

Not as much attention has been paid in the past to the production of beef cattle from pure stock as in the case of hogs. Most of the beef cattle in the county are grade Shorthorns, though there are a few purebred Shorthorn and a few Aberdeen Angus herds. Most of the beef cattle are raised locally, but several carloads are shipped in each year and fattened during the fall and winter months, principally in the northeast corner of the county and in the vicinity of Grimes. The beef cattle raised in the county are kept on pasture during the summer months. Finishing is usually done on roughage and concentrates. The packing houses in Des Moines take practically all the beef cattle sold in the county. The use of silos in cattle feeding is increasing annually.

Dairying in combination with general farming is expanding gradually. In 1919 the number of dairy cattle in the county was 14,769. There has been a steady increase in number for the last several years. As a rule dairying is carried on throughout the year. The cows are kept on pasture during the grazing season with some supplementary feed. In the winter months they are given ensilage or hay, with some concentrate. There were 203 silos in the county in 1917. The short hay crop of the last two years (1916 and 1917) has stimulated their use. On the largest dairy farms the stock strains are pure, and there are nearly 100 purebred herds in the county. The most popular breeds are the Holstein and the Shorthorn, though there are a number of Jersey and Guernsey herds. Most of the milk is sold as whole milk to the distributing companies in Des Moines. Collecting trucks traverse the most of the southern and north-central parts of the county.

The most important breeds of draft horses are the Percheron and the Belgian. Nearly every farmer raises one or more colts every year and in this way keeps up his supply of work horses and occasionally has a surplus to sell. There has always been a ready market for

good horses at Des Moines, where they are purchased for eastern markets.

The 7,351 sheep raised in the county in 1919 were owned, as a rule, in small flocks. Many more farmers would keep sheep if the menace from dogs were less. Several carloads of western sheep are fattened each year, principally in the vicinity of Grimes.

The more rolling land along the Des Moines River is used mainly for pasture. Most of the Wabash clay along the Skunk River has been kept in the native grasses and this also is utilized for pasture or mowing land. Much pasturing is done along the small creek bottoms and adjacent to the rivers where the soil is subject to overflow. Commercial orchards are restricted almost entirely to the silty soils. Most of the winter-wheat planting has been done in recent years on the alluvial and better drained upland soils of the county. The farmers recognize that the Webster silty clay loam and clay loam, where well drained, are excellent corn soils, but that small grains on these soils are inclined to grow too rank in wet seasons. Truck farming is most extensively practiced on the sandier terrace soils and on the darker colored silty soils of the uplands. It is realized that the former are rather poor corn soils. The Tama silt loam and the Carrington loam are considered the best upland soils for the growing of alfalfa.

In recent years more of the farmers of the county have realized the necessity of rotating crops according to a definite system. This has been brought about partly through the decrease in corn and wheat yields, resulting from the practice of continuous cropping and from the lack of sufficient live stock on many of the farms to supply the necessary manure for keeping up the yields. By the better farmers corn is now rarely grown over two years in succession, except in the case of newly broken land, marshy land, or first-bottom land. Here it may be grown four or even five years without an appreciable decrease in the yield. Alfalfa has not been grown extensively enough to be introduced into any regular rotation. The most common rotation includes corn one or two years, oats one year, and clover and timothy two years. Wheat may follow the oat crop for one year.

More attention is now given to the careful preparation of the seed bed, to the selection and grading of seed, and to the subsequent cultivation of crops than was the case in former years. Early frosts and a decrease in the quality of the corn have caused the planter to select his seed carefully and in good season. Nearly all the corn grown is check-rowed, though on the sandier types some is listed. A small quantity is drilled for ensilage or fodder. Corn is usually cultivated four or five times. The stalks are pastured after the grain is husked. Oats usually follow corn, and the seed bed is prepared

by plowing 4 to 6 inches deep and leveling with a harrow. Plowing in most cases is done on the heavier soils with five-horse teams and on the lighter types with four-horse teams. Many tractors are in use in the less rolling sections. Clover, timothy, or a mixture of the two is often planted with oats. After the grain crop is harvested, one cutting of hay is obtained. Any later growth is allowed to seed in order to provide pasture the following year. There may be some pasture the first year if the season is favorable. The land, if pastured, is plowed early the next spring and returned to corn. If left to the second year, the plowing is usually done in the fall. Many farmers report that corn usually yields about five bushels more per acre the first year following clover than the second. If winter wheat is placed in the rotation it follows oats, the plowing being done as soon after the removal of the oat crop as possible. Where clover and timothy follow winter wheat, timothy is usually seeded with the wheat and the clover sown in the spring.

Small grains are seldom grown two years in succession, as the yield is reduced the second season. Oats are usually sown broadcast, while wheat is drilled. Most of the small grain is thrashed from the shock, though much is stacked. It is a common practice, especially on rented farms, to sell the wheat and the surplus oats direct from the thrashing machine.

Good stands of alfalfa have been obtained from spring and also from August planting, either time of planting giving good results if the soil and moisture conditions are favorable. The crop gives three cuttings. Usually it occupies the land not longer than five years.

Sorghum of the saccharine varieties is most commonly planted to provide forage when the production of hay is decreased by adverse climatic conditions in the spring, but Sudan grass is replacing sorghum to quite an extent and with good results. The native prairie grasses are being crowded out by bluegrass. Some redtop grows in the wetter places. For pasture planting bluegrass is usually sown with clover and timothy, the bluegrass eventually taking the land.

On nearly all the farms in Polk County the most improved machinery is in general use. In 1917 there were 78 tractors on the farms and their use is increasing annually. The buildings over most of the county are of good size, well built and maintained, and indicate a general condition of thrift and prosperity. Practically all the fences are of barbed wire or a combination of barbed and woven wire. Cement or iron posts are used by many. The draft horses are large, heavy, and are well cared for.

The use of commercial fertilizers in Polk County is confined almost entirely to trucking and market gardening. In all very little is used. The manure that accumulates during the winter months on

the general farms usually lies in open lots until spread on the land, hence there is much loss in its fertilizing value. It is usually applied to the small-grain land or clover land just before plowing. In truck farming the manure is put on the soil as soon as practicable after it is made.

There is usually a plentiful supply of labor for the farms. Much of it is transient, however, and is not entirely satisfactory. The report of the State board of agriculture gives the average monthly wages for summer in 1917 as $37.90 and for winter as $37.88. The rate during the summer months ranges from $30 to $40 per month, including board and wash; that for winter is lower. Day laborers are paid from $2 to $3.50 per day, depending upon the season and the character of the work to be done.

There is some uncertainty as to how many of the smaller truck farms near Des Moines are classed as farms by the State report. They report, however, 2,445 farms in the county in 1917, with an average size of 121.5 acres to the farm. The 1920 census reports 2,948 farms in Polk County with an average size of 110.9 acres, ranging from farms under 3 acres in size to 1 farm of more than 1,000 acres. The general trend is toward larger farms in the outlying districts by the combining of two or more farms, while close to the city the tendency is to divide the farms into smaller tracts. Most of the farms in 1919 comprised from 100 to 174 acres. Of 326,840 acres of farm land in 1919, 283,211 acres, or 86.7 per cent, was classed as improved land.

Since about 1880 the proportion of tenant farmers has gradually increased. The 1915 State census reports 41 per cent of the farms operated by tenants, and practically all the remainder by the owners. The numbers given are 982 farms operated by owners, 452 by owners with some leased land in addition, 506 leased for cash, 325 leased for a share, and 342 leased for cash and a share. The 1920 census reports 56.3 per cent operated by owners, 42.6 per cent by tenants, and 1.1 per cent by managers. Most of the leases are for one year. Cash rents varied in 1917 from $5 to $10 an acre. Share tenancy is usually on a basis of two-fifths or one-half of the grain produced, with a cash consideration for the pasture land, which rents for $3 to $6 an acre. The share tenant ordinarily is required to deliver or store the product paid as rent. The prevailing prices of good farm land range from $175 to $225 an acre.

SOILS.

The soils of Polk County are not related to the underlying indurated rock formation, but come from more recent deposits of Pleistocene age. They fall into three general groups, according to the material of which they are composed and the methods of accumu-

lation. The first group comprises the soils derived from glacial drift laid down by the Wisconsin and Kansan ice sheets, and unmodified except for surface weathering. The Webster, Carrington, Shelby, and Lindley soils belong to this group. The second group includes the soils formed by the weathering of the silty material usually designated as the Iowan loess. These are the Tama and Clinton soils. The third group comprises the reworked material most of which has come from the Wisconsin drift, with occasionally an admixture of material washed from the silty material. This group occupies the various terraces and bottoms of the streams, and includes soils of the Bremer, O'Neill, Waukesha, Buckner, Chariton, Lamoure, Wabash, and Sarpy series.

The major physiographic features of the county are due to the Coal Measures, the lowest formation exposed in the area.[3] They represent the upper strata of the Carboniferous and are composed mostly of a mixture of argillaceous shales with thin beds of limestone, sandstone, and occasional seams of coal. The exposures of this formation, however, are few and small.

The minor physiographic features of the county are formed by the erosion of the Pleistocene mantle, which is composed of the Kansan drift, the silty material, and the Wisconsin drift in the order named. The Kansan drift consists chiefly of a stiff blue clay containing numerous greenstone pebbles and small bowlders. Small pockets of sand and gravel may occur above or in this clay stratum. The exposures of this drift found most commonly under the silty material in the southern part of the county appear brown to red in color, owing to oxidation. They give rise to small areas of loamy soil which are classed with the Shelby series, or, as is the case along the steeper slopes to the north of the Des Moines River, they form a sandy soil which is correlated with the Lindley series. The total area of soils derived from the Kansan drift is, however, relatively small.

In the silt-covered region the topography is more rolling than in the drift-covered parts and exposures of the underlying strata are rarely seen. This layer of silty material varies in depth considerably, but the average depth is between 10 and 20 feet. It is characterized by a buff color, a smooth, very fine grain, and freedom from pebbles. A few small pockets of fine sand are found in it, but these are not extensively distributed. Indications are that it was originally quite calcareous, but the lime has been leached to depths of more than 30 inches, below which it has been segregated into nodules. The soils derived from this material occur south of a line drawn southwest from Nobleton through Risingsun to the Des Moines River, and thence west to the county line. The weathering of this material

[3] Statements appertaining to geology are taken from the Geology of Polk County, by H. F. Bain.

and eventually the establishing of prairie growths and the addition of organic matter has given rise to the Tama series, and, on the steeper slopes where conditions were unfavorable to the incorporation of organic matter, to the Clinton series.

The upper drift sheet, the Wisconsin, occupies the northern four-fifths of the county and has been modified only by weathering. It varies considerably in thickness—from about 75 feet in the northern part of the area to a few feet along its southern border. It is composed of an unstratified mixture of clay, silt, and sand in varying proportions, with here and there beds of stratified gravel. Two small kames underlain by a thick bed of gravel occur west of Crocker and east of Kelsey. Bowlders and pebbles of granite, gneiss, and quartzite are scattered over the surface and through the mass of the drift. Many of the bowlders are large. The drift in its natural state varies in color from bluish-gray to very pale-yellow. The unweathered material is usually calcareous, but the carbonate has been leached out to a depth ranging from 2 to 10 feet, depending on the texture. The naturally level to gently undulating surface of most of this drift favored the luxuriant growth of grasses, and hence the accumulation of organic matter and the development of such soils as those of the present Webster and Carrington. Where conditions were unfavorable for the accumulation of organic matter, the resulting soil is of the Lindley series.

In the saucerlike or gently undulating topography of the uplands in the northern three-fourths of the county, where water collected in depressions for indefinite periods, fine material has washed in from the adjacent slopes, resulting in the filling up of such with a heavy soil or in the accumulation of the remains of plants to form Peat.

The soils derived from the reworked glacial and silty materials may be subdivided into two groups upon the basis of their topographic position, viz, terrace soils and recent alluvial soils.

The terrace, or second-bottom, soils occur in nearly level benchlike areas, lying from 5 to 40 feet above the first bottoms along the larger streams. These soils are practically free from overflow. Most of the older and higher terraces occur in the Wisconsin drift region of the county. These highest terraces lie 15 to 40 feet above the present flood plain of the larger streams and may be considerably dissected in places by smaller drainage ways. In most of the areas the basal material consists of an assorted mass of sand and gravel with more recent depositions of Wisconsin material on the surface. Along the Skunk River and the upper course of Beaver Creek, however, the basal material is loose, reworked bowlder clay. The soils found on the older terraces are mapped in the O'Neill, Waukesha, Buckner, and Chariton series.

The more recent high terraces lie from 5 to 15 feet above the present overflow land and have a basal material which is usually rework glacial or a reworked mixture of glacial and silty material. as is the case in the southern part of the county. A few small areas occur along the larger creeks and along the rivers where the understratum is coarser material. These recent high benches are usually the result of outwash from the drift or are depositions by the present streams when they flowed at a higher level. A few in the southern part of the county have a distinctly silt-mantled surface. The dominant series found on the lower bench is the Bremer, though all of the above-mentioned terrace soils occur. Practically all of the high-terrace material in the surface 36 inches is not calcareous enough to give a reaction with hydrochloric acid.

Since reaching their present level most of the larger streams have deposited on their flood plains material washed from the higher lying glacial drift and silty soils. The first-bottom soils along the Des Moines River and its tributaries in the drift region are predominantly loamy to sandy. Those along the Skunk River, where the stream has a lower gradient, are of very heavy texture. In the silt-covered part of the county they are quite silty. The first-bottom soils of the county are classed in the Sarpy, Wabash, and Lamoure series. The latter two are usually rather high in organic matter, and the Sarpy and Lamoure are distinctly calcareous.

The various soils of the county are separated into series on the basis of origin, color, structure, and topography. The series are subdivided into soil units, or types, on the basis of texture, which is determined by the relative proportions of sand, silt, and clay present. In Polk County 6 soil series embracing 9 soil types are mapped on the upland, 5 series including 11 soil types on the high terraces, and 3 series with 11 types on the first bottoms. Besides these normal soils there are also distinguished on the map, areas of Muck and Peat and Riverwash.

There follow brief descriptions of the various series as standardized not only for this county but for the general region of their occurrence.

The soils of the Carrington series are dark brown to black in the surface section and yellow to light brown in the subsoil. They are derived from the weathering of glacial till. The topography is gently undulating to rolling. Both soil and subsoil may contain a small proportion of gravel and bowlders. The series is only moderately calcareous, though the lower subsoil may give a slight reaction with hydrochloric acid. Two types of this series, one with a phase, are found in Polk County, the Carrington fine sandy loam and loam and the shallow phase of the latter.

The types in the Shelby series are characterized by dark-brown to almost black soils, brown to light-brown heavier upper subsoils, and light-brown to pale-yellow, loose sandy or gravelly clay lower subsoil. In places there is a substratum of loose sand and gravel. The surface soil is normally shallower than in the Carrington soils. The subsoil may be highly calcareous. The topography varies from knolly to gently or steeply rolling. One type, the Shelby loam, is mapped in this area.

The types included in the Webster series are characterized by their black surface soils and gray to yellowish-gray heavy subsoil. The subsoil is calcareous and usually effervesces with hydrochloric acid in the lower depths. The surface soils are darker colored than those of the Carrington and Shelby series. The surface is nearly level to undulating. The series has been formed through the weathering of glacial drift under conditions of poor drainage. Two types are mapped, the Webster clay loam and silty clay loam.

The Lindley soils are light brown to grayish brown or brownish gray in the surface. The upper subsoil is a mottled brown and gray compact heavy material, while the lower subsoil is a brown to yellowish-brown compact gritty clay. This series is derived from the weathering of drift material, where erosion has been active enough to prevent the accumulation of much organic matter. The topography is rolling to steeply rolling. The soils were originally covered with a growth of oak and hazel brush. One type occurs in this county, the Lindley fine sandy loam.

The surface soils of the Tama series are dark brown to black in color, and underlain by yellowish-brown to brownish-yellow subsoils. The Tama silt loam is characterized by its smooth, even texture and freedom from pebbles or rock fragments. In the typical state the surface soil is quite high in organic matter, but in the shallow phase much of the dark-colored soil has been washed off. The Tama soils in this county are formed from the silty parent material. Though this material was originally calcareous the lime has been leached to a depth of 36 inches or more. The topography is rolling. The Tama silt loam, with its shallow phase, and the Tama loamy fine sand are mapped.

The types included in the Clinton series are characterized by gray or brownish-gray to dark-gray soils and light-brown or yellowish-brown compact lower subsoils. The upper subsoil in this county contains brown and gray mottlings, and is not as compact as the lower subsoil. Neither the surface soil nor subsoil is highly calcareous. The topography is rolling to strongly rolling. The series has the same origin as the Tama, but has been formed under conditions of greater erosion. It differs from the Lindley series in surface appearance, mainly in its more uniform texture and the absence

of coarse material. In Polk County only one type of the Clinton series, the silt loam, is developed.

The Bremer series comprises soils that are dark brown to black in the surface section and dark grayish brown to dark brownish gray in the subsoil. The subsoil to a depth of 3 or more feet is as heavy as, or heavier than, the soils. There is not enough lime in any part of the soil section to cause effervescence with hydrochloric acid. The series is confined to terrace outwash plains and more recent water-laid material now lying above overflow. The soils are poorly to fairly well drained. They differ from the Wabash soils in occupying positions above overflow. Four types occur, the clay, silty clay loam, loam, and silt loam.

The types of the Chariton series are similar to the Bremer in origin and position. They have dark-gray to dark-brown soils. The subsoil in the upper part is an ashy-gray silty material and in the lower part a drab to mottled brown and drab compact silty clay to clay, splotched with numerous reddish-brown iron stains. Drainage is poor to fairly good. The lime content is low. One type, the silt loam, is mapped in Polk County.

The Buckner series consists of types with brown to dark-brown surface soils and lighter colored, friable subsoils. The origin and position is the same as in the Bremer series. The surface is level, but drainage is good. The fine sandy loam is the only type mapped in this county.

The surface soil of the types included in the Waukesha series is dark brown to black. The subsoil is light brown to yellowish brown and heavier in texture than the surface soil. Neither soil nor subsoil is highly calcareous. This series occupies benchlike areas along the streams and consists of reworked material of mixed origin. The areas are above overflow. Drainage is good. The loam and silt loam types are developed.

The O'Neill series differs from the other high-terrace soils in having a substratum of gravel or sand within the 3-foot soil section. The surface soils are dark brown to nearly black and rest on light-brown to brown subsoils. The soils are inclined to be somewhat droughty. The O'Neill fine sandy loam, loam, and fine sand are mapped in this county.

The Wabash soils differ from the Bremer only in their physiographic position. They are developed in first bottoms and are subject to overflow. A distinguishing feature is the high content of organic matter. This series is represented in this county by the fine sandy loam, loam, silt loam, silty clay loam, and clay.

The Lamoure types are distinguished from the Wabash mainly by their high lime content both in the soil and subsoil. The surface soils are very high in organic matter and dark colored, while the

subsoils are dark drab to light drab or yellowish drab. They are level and poorly drained. One type, the silty clay loam, is mapped.

The Sarpy series includes types with brown to brownish-gray or grayish-brown soils, underlain by lighter textured subsoils, frequently passing into loose sand within the 3-foot section. Both soil and subsoil are calcareous. The surface soils are somewhat deficient in organic matter. The soils of this series are subject to overflow. The loam, fine sandy loam, very fine sandy loam, silt loam, and silty clay loam occur in this area.

Soils made up of the organic remains of water-loving plants and grasses accumulated in ponds or lakelike depressions are classed as Muck and Peat.

Riverwash includes small areas of nonagricultural, coarse-textured soil along the channels of the Des Moines and Raccoon Rivers, where the material is shifted and altered with each rise of the stream.

The various soils encountered in Polk County are described in detail in the following pages of this report and their relation to agriculture discussed. Their distribution is shown on the accompanying map, and their actual and relative extent in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Carrington loam	118,656	32.9	Bremer loam	3,328	0.9
Shallow phase	3,584		Sarpy very fine sandy loam	3,328	.9
Webster clay loam	63,168	17.0	Wabash silty clay loam	2,816	.8
Tama silt loam	37,056	11.1	Buckner fine sandy loam	2,752	.7
Shallow phase	4,608		Waukesha silt loam	2,560	.7
Webster silty clay loam	16,256	4.4	O'Neill loam	2,048	.6
Wabash clay	15,168	4.1	Wabash silt loam	1,920	.5
Waukesha loam	13,696	3.7	Sarpy silt loam	1,280	.3
Clinton silt loam	12,352	3.3	Bremer clay	1,088	.3
Carrington fine sandy loam	9,280	2.5	Riverwash	896	.2
Wabash loam	8,512	2.3	Muck and Peat	832	.2
Lindley fine sandy loam	6,976	1.9	Wabash fine sandy loam	640	.2
Bremer silty clay loam	6,656	1.8	Tama loamy fine sand	512	.1
Sarpy loam	6,464	1.7	O'Neill fine sand	512	.1
Shelby loam	5,312	1.4	Sarpy fine sandy loam	512	.1
Lamoure silty clay loam	5,184	1.4	Chariton silt loam	320	.1
O'Neill fine sandy loam	4,928	1.3			
Sarpy silty clay loam	4,800	1.3	Total	372,480	
Bremer silt loam	4,480	1.2			

WEBSTER CLAY LOAM.

The surface soil of the Webster clay loam is a very dark brown or nearly black clay loam about 15 inches deep. This is underlain by a dark yellowish brown, rather compact, crumbly clay loam, which at about 24 inches becomes a yellowish-gray or grayish-yellow gritty

clay loam or clay. In areas adjacent to lighter textured soils the surface 2 to 4 inches may be quite loamy. The surface soil contains a large percentage of organic matter. Reddish-brown iron stains are numerous in the subsoil. Glacial bowlders and gravel are not as common on the surface or through the soil section as in the case of the Carrington loam. The surface soil and upper subsoil rarely contain enough lime to effervesce with hydrochloric acid, but the lower subsoil often does.

This soil has undergone very little modification from its original condition as glacial till, except by the addition of organic matter. The surface soil is quite uniform in depth over the entire area of the type. Unless properly cultivated, it forms clods and is somewhat refractory, and in dry seasons it is inclined to bake and crack. It requires heavier draft power for tillage operations than the other upland soils, with the possible exception of its related type, the Webster silty clay loam, many small areas of which are necessarily included with this type because of their small extent. The soil originally supported a luxuriant growth of slough and prairie grasses, with a scattering of redtop in the marshy spots. There was practically no timber.

This soil occurs on the flatter divides within the Wisconsin drift region in the northern three-fourths of the county. The general topography of these divides consists of a nearly level to gently undulating surface with tortuous winding swales, which cause it to have a "saucerlike" or billowy appearance. The Webster clay loam usually occupies the gentle slopes and flatter basins of this surface, with the Carrington loam on the crests, though it may cover the whole surface over large areas. Some areas occur on long, very gentle slopes to well-defined drainageways. Other bodies occupy the flatter crests, especially those east of the Skunk River and those near the southern extremity of this drift material. The largest continuous bodies of this type lie between Mitchellville and Elkhart, and from Ankeny northwest to Sheldahl. Farm tractors can be used to advantage on practically the whole type.

The surface drainage and internal drainage are very slow, owing to the level topography and the heavy nature of the subsoil. The surface run-off over most of the type is through very broad U-shaped intermittent drainageways, or swales. These have very low gradients and much of the water sinks into the soil. Most of the type has been tile drained. On the more sloping areas to the better established drainage ways the surface drainage is more adequate, but even here tile drainage is used to effect better underdrainage. This soil is very retentive of moisture, and crops rarely suffer from drought.

The Webster clay loam, when well drained, is one of the most desirable soils in the county for general farming. It includes no waste land and practically all of it is under cultivation. The important crops are corn, oats, hay, and wheat. Corn is the principal cash crop, with oats second. About 40 per cent of the corn produced is put on the market. As a rule corn matures a few days later than on the sandier upland types, owing to the necessity of planting later in the spring and to the slower development of the plants where the soil is poorly drained. Cultivated grasses are being grown more extensively each year in systematic rotations and used in the feeding of live stock. Alfalfa is grown on this soil only in small fields. Fruit is not grown very extensively. The main live-stock industries are the raising and fattening of beef cattle and the raising of hogs. The dairying industry has developed considerably in recent years, especially in the districts where delivery of milk to Des Moines is convenient.

This soil is very productive for most of the grain crops grown in this region. The average yield of corn is 40 to 50 bushels per acre.[5] In very favorable years a yield of 65 to 75 bushels per acre is not uncommon. Oats ordinarily yield 30 to 40 bushels per acre and winter wheat 18 to 23 bushels. Little barley or spring wheat is grown. They usually give lower yields than winter wheat. Timothy and clover, mixed, ordinarily produce about 2 tons of hay per acre, red clover alone 1¾ to 2 tons, and timothy 1¼ to 1¾ tons. Clover and winter wheat winterkill at times, especially when there is much heaving during the winter months, followed by a dry spring. When the hay crop is short, millet may be grown as a supplementary feed.

A new industry on this soil in the vicinity of Altoona, Grimes, and Maxwell (in Story County) is the growing of sweet corn and pumpkins for the canning factories. Averages for the last three or four years place the yield of sweet corn at 3 to 5 tons per acre and pumpkins at about 3 tons. This industry requires a shorter growing season than in the case of field corn and gives considerable green forage for live stock in the fall.

While the Webster clay loam is usually quite friable in the surface 3 or 4 inches, care must be taken not to cutlivate it when too wet, as it forms clods which are slow to break down. In wet seasons the planting and cultivating of crops on this soil is greatly retarded; it is one of the last of the upland soils to warm up in the spring.

By employing the proper methods of handling, such as those followed by the more progressive farmers, the productiveness of this soil can be easily maintained. Most of the farmers recognize the value of crop rotation and many follow a definite system with ex-

[5] Statements as to yields on the various soils are based on information obtained from farmers.

cellent results. The rotation in most common use is corn two years, oats one year, followed by mixed timothy and clover for two years, after which the land is returned to corn. If winter wheat is grown it usually follows oats or is planted in the corn either while the corn is standing or after its removal for ensilage. Many farmers report that the first crop of corn after clover yields from 4 to 6 bushels more per acre than the second crop. The best farmers keep enough live stock to use most of the corn they grow, and in this way a considerable supply of barnyard manure is returned to the fields. This is usually applied to the small-grain land or to the clover sod that is to be plowed in the fall.

The farms are in general well improved. Some of the best in the county are located on this soil. Most of them are thoroughly tiled. Permanent wells can be obtained by drilling to depths of 75 to 200 feet, though often a source of good water is found at less depth. Most of the farms range in price from $200 to $250 an acre. The value depends largely upon the location and the improvements, of which the tile system is an important feature.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Webster clay loam:

Mechanical analyses of Webster clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332861.....	Soil.....	0.6	6.8	8.2	25.6	7.0	34.5	17.2
332862.....	Subsoil.....	1.7	6.2	5.9	19.6	8.0	40.7	17.5

WEBSTER SILTY CLAY LOAM.

The Webster silty clay loam, to the depth of about 18 inches, is a very dark brown or nearly black silty clay loam. This is underlain by a dark-brown to dark-drab clay which grades at about 24 inches into a yellowish-gray to grayish-yellow, rather dense, clay loam or clay. The surface soil is high in organic matter. The subsoil in most places shows numerous reddish-brown iron stains and small lime concretions. Both soil and subsoil are highly calcareous.

In some of the lakelike depressions the soil may be quite peaty[6] in the surface 3 to 5 inches. Clay spots may occur in the center of a few of the areas, or, where adjacent to the Carrington soils, the soil may be loamy.

The Webster silty clay loam differs from its closely associated type, the Webster clay loam, in being darker colored, in containing

[6] When such material is over 6 inches deep the soil is mapped as Muck and Peat.

more silt in the surface soil, and in occupying lower topographic positions. When wet it is very sticky, but upon drying does not crack as badly as the clay loam, on account of its higher content of organic matter.

Small strips of soil containing an excess of soluble salts occur in places in the Webster silty clay loam, usually around small pondlike depressions or along recently drained areas. Crops do not give satisfactory yields here. In some of the strips the surface material shows a very thin incrustation when dry, an accumulation of salts having resulted through evaporation of the soil moisture. This so-called alkali consists mainly of calcium.[7] The total area of alkali soils in this county is very small, the individual strips rarely exceeding 50 feet in width.

The Webster silty clay loam occurs mainly over that part of the county where the Webster clay loam is the principal type, and its areas are usually surrounded by the Webster clay loam. A few small areas are located within areas of the Carrington loam. It owes its origin to the same agencies as the clay loam. It, however, occupies narrow strips in the lowest portion of the depressions along the sluggish drainageways, or occurs as larger irregular patches that appear to be old glacially formed lakelike ponds or marshes, recently drained. Along the edges of the upland drift soils it may extend, where the gradient is relatively high, a short distance down the drainage ways, and contain some alluvial material in the surface soil. The largest areas of this soil lie near Bondurant and north of Ankeny.

The surface of the Webster silty clay loam is nearly level, and the drainage is naturally very poor. In many of the unimproved areas water stands on the surface for some time after heavy rains. Surface drainage is even slower than in the associated clay loam type, and, unless thoroughly ditched and tile drained, it is the last upland soil to warm up in the spring.

A considerable proportion of this soil is cultivated in conjunction with the clay loam, and crop yields are said to equal, and in some cases to surpass, those obtained on that type, especially in the case of corn. That is, of course, if the soil is properly drained. In wet seasons small grains lodge badly, and efficient tillage of cultivated crops is difficult.

Much of this soil has been kept in the native grasses. This is especially true in some of the larger areas and in areas where water is likely to cover the surface very long after rains. The soil naturally supports a luxuriant growth of the finer slough grasses and blue-

[7] See Bul. 157, Improving Iowa's Peat and Alkali Lands, by the Iowa Agri. Exp. Station.

grass and makes excellent pasturage and mowing land. Slough grass yields 1 to 1½ tons of hay per acre.

Little barnyard manure is applied to this soil, except in attempts to improve conditions in the small spots of alkali. The type sells for as high a price as the Webster clay loam, if properly drained. The undrained areas ordinarily sell for less. This soil is ordinarily included in farms with adjoining types.

The most satisfactory method of preventing the surface appearance of alkali and of ridding the soil of the harmful salts, as reported by farmers, is to place a sufficient number of lines of tile around and through the affected area to carry away the water rapidly. To aid in hastening the removal of the salts after the drainage system has been established, most farmers make liberal applications of barnyard manure to produce acids which react with the salts. The Iowa experiment station recommends the alternative of plowing under straw and green crops in cases where enough manure is not available.

CARRINGTON FINE SANDY LOAM.

The surface soil of the Carrington fine sandy loam is a dark-brown to dark grayish brown fine sandy loam. This is usually underlain at about 15 inches by a brown to yellowish-brown fine sandy loam which may grade into a loamy fine sand or fine sand near the lower limits of the profile. Where the soil is in the native sod or has received careful treatment the content of organic matter is moderately high, though not as high as in the Carrington loam. In some places the organic matter has been allowed to leach away and the surface soil is a grayish-brown color when dry. Near the areas of heavier soils the surface soil may be quite loamy and the subsoil a heavy loam or light silty clay loam.

Over most of the area of this soil the material is comparatively uniform. It is almost free from glacial bowlders and gravel. The surface was originally covered with grass and in many areas supported some forest growth.

The Carrington fine sandy loam occurs chiefly on smooth and rather gradual slopes to the north of the Des Moines River and along Skunk River, Indian Creek, Big Creek, and Little Beaver Creek. The largest continuous area, which embraces about 5 square miles, lies along the Skunk River. A few of the smaller areas bordering the small creeks are steeply rolling. The type is well drained. The internal drainage is rather rapid, but in most places the subsoil is compact enough to retain moisture fairly well. In years of normal rainfall this soil is as productive as the Carrington loam, but prolonged dry spells during the growing season are likely to reduce yields, especially on the areas with the lighter textured subsoils.

Probably 60 per cent of this soil is under cultivation, the remainder being used for pastures. Corn, oats, and wheat are the principal crops. Very little alfalfa has been planted. A smaller proportion of the land is devoted to hay crops than on the Carrington loam. In the vicinity of Des Moines watermelons, cantaloupes, sweet potatoes, and other truck crops and small fruits are grown with good results, providing the organic content of the soil is carefully maintained. Beef-cattle raising and fattening is the most important live-stock industry, and considerable feeding is done on this soil south of Loring.

On account of the light texture and good drainage, this is an early and easily managed soil. It can be tilled under a wide range of moisture conditions without danger of baking or forming clods. The type is handled in much the same way as the Carrington loam, though lighter draft power can be employed. For strictly farming purposes the value of this land ordinarily ranges from $150 to $200 an acre.

Owing to the rather low organic matter content of this soil, it is advantageous to make frequent applications of barnyard manure and to turn under cornstalks, the straw of small grain, and other crop residues. The growing of clover and the plowing under of an occasional crop would prove beneficial.

CARRINGTON LOAM.

The Carrington loam consists of a dark-brown mellow loam underlain at about 12 inches by a brown to dark yellowish brown heavy loam. The lower subsoil, commencing at 18 or 20 inches, is a yellowish-brown to brownish-yellow, somewhat gritty, silty clay loam, or bowlder clay. An occasional bowlder is encountered on the surface or through the soil section, and the occurrence of small glacial pebbles is not uncommon. In no place, however, are these rock fragments so numerous as to interfere seriously with cultivation. The surface soil is moderately high in organic matter. As a rule neither soil nor subsoil contains enough lime to effervesce with hydrochloric acid, though a slight reaction may be obtained in the lower subsoil in the areas of shallower soil.

The Carrington loam on the slopes along the east county line near Farrar, along the west county line near Granger (in Dallas County), and near Campbell is shallower than typical, the surface soil rarely exceeding a depth of 8 or 10 inches. Here the content of organic matter of the surface soil is lower and the sand content higher, the upper 2 or 3 inches in many places being approximately fine sandy loam. The whole soil section is not as compact as on the divides. Small spots occur on the sharpest slopes which resemble

the Shelby loam. They have a grayish cast in the lower subsoil and are slightly calcareous. This last variation is also found in small spots on sharp slopes near the southern limit of the Wisconsin drift. These areas are not typical, but belong with the Clarion series. Owing to their small extent they were not separated on the soil map of this county. On some of the smaller knolls or minor elevations of the Carrington loam which occur over the flatter divides in the northern part of the county the lower subsoil is quite sandy and incoherent. Near areas of the Webster soils the surface soil may have a higher clay and a higher organic matter content, but the line between the two is fairly distinct because of the much darker color of those types. The areas of Carrington loam occurring in the silty region of the county have a rather shallow surface soil and a reddish-brown, gritty clay subsoil.

Most of the Carrington loam in Polk County has a strongly undulating to gently rolling topography. Its main occurrence is along the drainageways, though considerable of it lies in small bodies on the minor elevations in the flatter regions. The largest continuous area, broken only by small strips of alluvial land, lies along the southern edge of the Wisconsin drift, extending west from Mitchellville through Des Moines to the west county line. Other large areas occur on the divide between Skunk River and Indian Creek, along Big Creek, and south of the Des Moines River near Grimes. Practically all the slopes are smooth and regular in outline.

Over the most of its occurrence the drainage of the Carrington loam is good. Artificial drainage has proved beneficial in some of the smaller flat areas surrounded by the Webster soils and on the slopes of lower gradient. Excessive washing seldom, if ever, occurs in the typical development. The subsoil, as a rule, retains water well, but is less retentive than that of the Webster soils.

The Carrington loam is the most extensive soil in the county and very important in its agriculture. Probably 80 per cent is under cultivation, some of the more rolling areas having been kept in the native state for pasture. The soil originally supported a good growth of prairie grasses which have been displaced to a considerable extent in the uncultivated areas by bluegrass. The forest growth, which occurred principally in the rolling areas, was composed mostly of oak, ash, elm, hickory, locust, hackberry, and wild cherry, with undergrowth of hazel and buck bush.

Most of this type is well adapted to the use of labor-saving machinery. All the common crops grown in this region are produced. Corn is the principal cash crop, with oats and wheat second in importance. Probably a larger percentage of the corn and oats produced is fed on the farm than is the case on the Webster clay loam. The acreage devoted to cultivated grasses is greater. Winter wheat

is more commonly grown and spring wheat has been introduced successfully in the last few years. Clover and timothy are the main hay crops, though some native hay is cut on the more rolling areas. Alfalfa has given fairly good results where a stand has once been obtained, and the failures experienced with this crop are reported to be due usually to unfavorable seasons. Some losses occur through the killing of leguminous crops when severe winters are followed by dry springs, though alfalfa seems to stand the unfavorable condition better than clover. Good results have been obtained on this soil in the southern part of the county with apples, cherries, and grapes, when proper care has been given the trees and vines. Some trucking is done in the vicinity of Des Moines.

Important live-stock industries include the raising of hogs, the raising and fattening of beef cattle, dairying, and the feeding of hogs, cattle, and sheep. Many breeders of purebred stock farm on this type. The raising and feeding of beef cattle is most common along stream bottoms, which afford a good quality of summer pasturage and good supplies of hay. Most of the feeding of shipped-in stock is done along the Skunk River and in the west-central part of the county. Dairying is practiced most extensively within easy hauling distance of the city and along the interurban electric railways.

Yields on this soil vary somewhat with the position on the slopes or flat divides, and with the content of sand and the compactness of the subsoil. Ordinarily yields are about as follows: Corn, 35 to 40 bushels per acre; oats, 35 to 45 bushels; winter wheat, 18 to 25 bushels; and spring wheat, 18 to 20 bushels. Sweet corn, which is produced extensively in the vicinity of the canning factories, yields from 2½ to 3 tons in the average year. Pumpkins, on the same ground, produce about 3 tons. Clover and timothy mixed yield 1½ to 1¾ tons per acre annually; clover alone 1 to 2 tons; timothy 1 to 1½ tons; and alfalfa 2½ to 3 tons.

This soil is easily cultivated and a good tilth may be maintained throughout the year. Heavy farm implements are used, but less draft power is required than on the Webster soils. The soil warms up quickly in the spring, except near poorly drained areas of other types, and it can be cultivated and seeded early.

The value of crop rotations is generally recognized, and definite systems covering five or six years have been adopted by many of the farmers. The rotation and methods of handling are much the same as those on the Webster clay loam. Corn yields decline on areas where the crop is grown many years in succession. Alfalfa has not been grown extensively enough to be given a definite place in the rotation system. It does not usually occupy the land for more than five years. It yields three cuttings annually. Where permanent

pasturages are planted bluegrass is usually seeded with timothy and clover, the bluegrass gradually dominating the stand.

Farms on the Carrington loam are usually well improved and prosperous. Good live stock is kept. Land of the type ordinarily sells at $175 to $225 an acre, depending upon the condition of the soil, the topographic position, the location with reference to markets, and the improvements.

The use of a cover crop on some of the steeper slopes would prove beneficial in preventing washing and leaching. The addition of more organic matter, either in the form of barnyard manure or green manuring crops, is needed on some of the more rolling areas.

Carrington loam, shallow phase.—The shallow phase of the Carrington loam includes rolling or sloping areas in which the surface soil is very shallow, rarely attaining a depth of more than 6 inches. The soil is usually lighter colored than in the typical development, and frequently in cultivated fields the subsoil is turned up with the plow, exposing a brown to yellowish-brown silty clay loam. The texture of the surface soil is also sandier than in the typical soil. The subsoil is typical bowlder clay, but may grade into a grayish-yellow silty clay loam in the lower depths on some of the steeper slopes. Bowlders and glacial pebbles are in places quite numerous in the subsoil. On the other hand, on some of the more gradual slopes the entire soil section may be free from rock fragments and the subsoil distinctly compact.

This phase occurs scattered over the drift region of the county in small, irregular-shaped areas. Its normal position is on the rolling slopes of the larger creek valleys; a few areas, however, lie on gentle slopes and near the heads of drainage ways where erosion has been quite active. The phase differs from the Shelby loam in that it has a more compact subsoil, contains a smaller percentage of gravel, and is less calcareous.

This phase is not important agriculturally and is of relatively small extent. Most of it is used for pasture, being too steeply rolling for profitable cultivation. This part supports a growth of native prairie grasses with some forest trees, chiefly oak, elm, hickory, and hazelnut.

On the less rolling parts, where the land may be cultivated, it is farmed in conjunction with the surrounding soils. The yields of grain crops are not usually as satisfactory as on the typical soil, especially in the drier seasons. As a rule it has a slightly lower selling value than that soil.

The most pressing needs of the phase are the prevention of washing and the addition of organic matter. Where possible it should be kept in a cover crop during the fall and winter months. When plowed in the fall it should be broken deeply and left rough and

open. The phase declines rapidly in productiveness under poor management. Organic matter should be applied as heavily as practicable.

SHELBY LOAM.

To the depth of 8 or 10 inches the Shelby loam is a dark-brown to brown mellow loam. The subsoil is a brown to yellowish-brown, rather compact heavy loam to silty clay loam to 18 or 24 inches, and below this a brownish-yellow to grayish-yellow, rather loose silty clay loam or sandy clay. Ordinarily the content of organic matter in the surface soil ranges from low to moderate. Varying quantities of glacial bowlders and gravel, consisting of fragments of quartzite, gneiss, greenstone, granite, and limestone, occur throughout the soil and subsoil, although rarely in quantities large enough to hinder cultivation. The subsoil in some areas is more calcareous than in the typical Shelby loam and in many places it is splotched with numerous reddish-brown iron stains in the lower portions.

In a few of the areas lying on narrow ridges or knolls the soil is underlain at varying depths by a stratum of coarse sand and gravel with little admixture of clay. This is especially true in the small areas occurring in the northern part of the county and along the west county line. The content of organic matter in the soil is generally lowest in the more rolling areas, while on the flatter divides it is high enough to give the surface soil a very dark color. In some of the areas the soil is quite light textured and may be a fine sandy loam over small acreages.

The areas of the Shelby loam in this county are relatively small. Most of the type lies along the Des Moines River and its shorter tributaries from Des Moines north. Small areas, however, are scattered over the northern two-thirds of the county. The larger areas are for the most part irregular strips lying on a strongly and steeply rolling topography. Some of the areas close to the river have abrupt slopes and are dissected by deep, steep ravines, which expose nearly perpendicular walls of bowlder clay. The topography of many of the smaller areas and areas inland from the larger streams, is ridgy or knolly, or, as in the north-central part of the county, on the crests of the knolls rising above the Webster soils, may be flat. Surface drainage in the more rolling areas is inclined to be excessive; in the remainder of the areas it is more moderate.

Because of its small extent this soil has little influence on the local agriculture. Probably less than a third of it is under cultivation. The more rolling areas, where cultivation is almost impossible, and others where excessive washing would follow the breaking of the sod, have been kept in the native grasses and are used for pastures. Most of the areas along the streams originally supported a forest growth.

The principal crops are oats, corn, and wheat, named in the order of their importance. The chief live-stock industry is the grazing of cattle. The yields are good in favorable seasons, but are reduced by subnormal rainfall during the growing season, especially on the areas that have much coarse material in the subsoil. Corn yields ordinarily range from 25 to 35 bushels per acre and oats 45 to 50 bushels. The yield of wheat is fair. Sweet corn returns 2 to 2½ tons of green ears per acre. In areas large enough to sell separately, the Shelby loam ordinarily brings from $140 to $185 an acre.

This soil is early and easy to handle. It responds quite readily to applications of barnyard manure, but more manure than is produced on the average farm is necessary to supply the need of the soil for organic matter. Leguminous crops should be grown more extensively and an occasional crop turned under. Good results would follow the more general adoption of definite crop rotations. The steep slopes should be kept in the native sod or in cover crops to prevent erosion.

LINDLEY FINE SANDY LOAM.

The surface of the soil of the Lindley fine sandy loam consists of a grayish-brown fine sandy loam. The organic matter content is low The subsoil from 10 to 24 inches is a gray and brown mottled compact silty clay loam which gradually passes beneath into a brown to yellowish-brown, very compact, gritty clay. Below the 3-foot section the material is a yellowish-brown, gritty, friable clay mottled with numerous gray spots consisting of calcareous material. The surface soil contains a relatively high percentage of very fine sand, and on the flatter areas may be a very fine sandy loam. The subsoil shows numerous reddish-brown iron stains. The soil and subsoil are comparatively free from glacial bowlders, but considerable coarse sand and fine gravel are present in the lower subsoil. This soil in Polk County is derived from both the Kansan and the Wisconsin drift. The former material dominates in the southern part of the county, where there is also a small admixture of silt. This drift probably predominates also on the lower slopes in the northern part. The Wisconsin drift undoubtedly makes up the greater proportion of the soil in the higher lying areas. Small exposures of the rocks and shales of the pre-Kansas period are exposed in some of the deepest cuts along the Des Moines River, but these do not affect the soil.

The Lindley fine sandy loam, as mapped, includes small areas of soils that are not typical. They occur where exposures of Kansan drift are mixed with the silt, and it was not practicable to separate the resulting soils. Practically all of the undifferentiated material is found on the steeper slopes along the Des Moines River in

and below the city of Des Moines. Its surface is often almost perpendicular. The material consists largely of reddish-brown bowlder clay, coarse sand, buff-colored silt, and gray sticky clays, or a mixture of all of these. Rocks of the strata below the Kansan material are often exposed in the lower cross sections. These included areas have little value.

Practically all of the Lindley fine sandy loam is found along the Des Moines River. The largest bodies are in the vicinity of Polk and Camp Dodge. Other smaller areas, some of them narrow strips, occur north of Campbell, along the Raccoon River, in the southeastern part of the county, and in East Des Moines. The common position is on steep slopes, though in places the type extends up over the narrow, rather flat divides. On the steeper slopes the surface is generally dissected by numerous ravines, and the drainage is excessive; the less rolling areas have sufficient relief to afford adequate drainage. Much of the soil is too steeply rolling for profitable cultivation.

The Lindley fine sandy loam is not an important agricultural soil in this county. Less than half of it is under cultivation. It was originally a timbered soil, and much of it still supports a forest, consisting chiefly of oak, elm, wild cherry, hickory, hazlenut, and buck bush. There is a sparse growth of grass on the uncultivated area, and this land is utilized as pastures for cattle and horses.

This type is devoted to the same crops and handled in much the same way as the Carrington fine sandy loam. Small grains do well. A small acreage of truck crops is grown on it in Des Moines with fair results where organic matter is supplied. For agricultural purposes this land usually sells for $135 to $185 an acre, depending upon the topography, the nature of the native growth if uncultivated, the location, and the improvements.

The most urgent need of this soil is organic matter.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, subsoil and lower subsoil of the Lindley fine sandy loam:

Mechanical analyses of Lindley fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332863	Soil	1.7	4.9	3.9	23.8	19.3	18.9	27.3
332864	Subsurface	1.7	3.9	3.6	20.8	18.0	39.9	11.9
332865	Subsoil	2.0	7.1	5.6	20.9	15.7	34.8	13.8
332866	Lower subsoil	3.2	11.6	6.3	25.1	13.5	31.2	9.9

TAMA LOAMY FINE SAND.

The Tama loamy fine sand consists of a dark grayish brown loamy fine sand, underlain at about 15 inches by a lighter colored loamy fine sand or fine sand. The surface soil contains a moderate amount of organic matter. Adjacent to other upland soils the entire soil section may be slightly heavier textured than typical.

This soil is a minor type. It is developed in small bodies on the slopes to drainageways within the area of Tama silt loam in the western part of Bloomfield Township. The origin of this soil is rather indefinite, but it undoubtedly is reworked glacial material and has probably been transported to its present position mainly by wind action. Drainage is usually excessive owing to the open, porous nature of the soil and subsoil. The type originally supported a prairie vegetation with belts of forest trees along the larger streams.

Most of the Tama loamy fine sand is used for pasture. Corn, wheat, and oats are grown, but the yields over much of the type are below the county averages, especially in the drier seasons. Good results have been obtained in the production of watermelons, cantaloupes, and cucumbers after the soil has been built up by the addition of organic matter.

TAMA SILT LOAM.

The typical soil of the Tama silt loam consists of a dark grayish brown to dark-brown, smooth silt loam to the depth of 12 or 14 inches. The subsoil is a dark yellowish brown, slightly compact heavy silt loam which grades at about 22 inches into a friable, brownish-yellow light silty clay loam. Reddish-brown iron stains occur in many places in the lower subsoil. The entire soil section is remarkably free from coarse material.

This soil is derived from the weathering of silty material. In this county the parent deposit varies considerably in thickness, reaching a maximum of 75 feet or more in places, but the ordinary range is from 10 to 20 feet. Where it is very thin the stratum immediately underlying the soil section is a mottled brown or brownish-yellow and gray light silty clay loam and is quite friable. This mottled layer may come within the 3-foot section on the steeper slopes to the smaller drainageways. Where the deposit is thicker the substratum is a buff-colored calcareous material, the lime occurring in concretions. The material within the soil section has been thoroughly leached. The surface soil is deeper and darker colored on the divides and shallower and lighter colored on the slopes. Where the surface soil is 6 inches or less in depth the areas have been mapped as a shallow phase. The line between this soil and the Clinton silt loam is in many places rather indefinite, because of the similarity

of the parent material and the gradual change of the soil from its typical dark color to the lighter color characteristic of the Clinton.

The Tama silt loam occurs as the main upland soil in the southern one-fifth of the county. Practically all of it occurs in three large bodies, broken only by small stream bottoms and small areas of other soils. Two of these areas are north of the Raccoon and Des Moines Rivers, one east of Des Moines and one west. The third is south of these rivers, occupying by far the greater part of the country between the river and the county line.

The surface of this soil is smooth and rolling, the features becoming more even as the northern limits are approached and more rolling near the streams. The divides are narrow and smooth and the valleys distinctly V-shaped. Drainage is good except for narrow areas along some of the more sluggish streams in the northern part of the type.

The Tama silt loam is an important agricultural soil. Nearly all of it except that occupied by towns and farmsteads is cultivated. Originally most of the higher divides were covered with prairie grasses. Considerable bodies of forest grew on the slopes.

General farming prevails on this type. The leading crops grown are corn, wheat, and oats, named in the order of their importance. The raising of hogs and the fattening of beef cattle are the more important live-stock industries. There is considerable dairying in conjunction with general farming. Fruit growing is a profitable industry, and, with the possible exception of the Clinton silt loam, more apples and grapes are grown on this soil than on any other in the county, the majority of the larger commercial orchards and vineyards being on this type. Some truck growing is carried on south of Des Moines with good results. Blackberries, raspberries, strawberries, cabbage, beets, potatoes, beans, and onions are grown.

On the typical Tama silt loam corn ordinarily yields 30 to 40 bushels per acre, oats 45 to 50 bushels, winter wheat 20 to 27 bushels, and spring wheat 18 to 22 bushels. More spring wheat has been sowed in recent years than formerly, the crop displacing a part of the winter-wheat acreage. Red clover and timothy, mixed, yield about 2 tons of hay per acre, clover alone yields 1¾ to 2½ tons, timothy alone 1¼ to 1¾ tons, and alfalfa 2½ to 3 tons annually. On newer ground potatoes give good yields.

Over the type as a whole the soil is retentive of moisture. The surface soil is friable and can be cultivated under a comparatively wide range of moisture conditions. By employing the proper methods of handling, such as are followed by the more successful farmers, the productiveness of the type can be easily maintained. The best farmers recognize the value of crop rotations and follow a definite system. Corn is usually grown two years, oats one year,

wheat one year, and clover and timothy two years, after which the land is returned to corn. When spring wheat is planted it usually follows corn. Barnyard manure is most commonly applied to the oat stubble or to the clover sod before plowing for corn. Permanent pastures are established by sowing bluegrass with timothy and clover.

Farms on the Tama silt loam are, as a rule, well improved and well cared for. Water is obtained at depths less than 50 feet in dug wells and less than 150 feet in drilled wells. The usual selling price of farm land of this type is from $200 to $250 an acre. The price varies according to the improvements, location, and the condition of the land.

The use of cover crops during the winter months on the more rolling areas would tend to prevent much of the washing. The more general adoption of systematic rotations would prove beneficial in maintaining and increasing the soil fertility.

Tama silt loam, shallow phase.—The shallow phase of the Tama silt loam includes areas where the surface soil has been partly removed by wash and at present does not exceed 6 inches in depth. While considerable areas of the soil of this phase is dark brown, most of it has been modified in color by admixture of the yellowish-brown subsoil and is a dark yellowish brown to dark grayish brown.

Areas of the phase occur chiefly on the slopes near the heads of small drainage ways or on very narrow divides in country of generally rolling topography. The phase is the result of washing and may be due either to the erosion of the typical soil or to the slower accumulation of organic matter in sloping positions. The surface is smooth, the surface run-off is usually rapid, and drainage is in places excessive.

The phase is not extensive. The greater part of it occurs to the south of the Des Moines and Raccoon Rivers. About one-fourth of the total area is occupied by the city of Des Moines. Of the remainder approximately 60 per cent is under cultivation and is devoted to the same types of farming and the same crops and is handled in the same way as the typical soil. The rest of the land is used chiefly for pasture. It supports a growth of prairie grasses and bluegrass, with some forest trees. It is ordinarily sold in farms with the typical soil.

The principal deficiency of the soil is organic matter. This can be supplied by planting to a cover crop as much as possible during the fall, winter, and spring, to keep the surface from washing badly; followed by the addition of barnyard manure and the plowing under of all the crop residue that accumulates. In order to have a greater production of barnyard manure more live stock should be carried on the farms.

CLINTON SILT LOAM.

The surface soil of the Clinton silt loam, locally known as "ashy-gray land," consists of about 7 inches of brown to light-brown or, when dry, grayish-brown smooth silt loam. The subsoil is a mottled brown or brownish-yellow and gray heavy silt loam which passes abruptly at about 18 inches into a brownish-yellow or yellowish-brown very compact, though not impervious, clay. The soil section is remarkably free from grit, though a noticeable quantity of smooth very fine sand is present in the surface soil in places on the slopes. Locally, the brown and gray mottling may continue downward through the compact lower subsoil. This, however, is not common. Below a depth of 4 feet the material is buff colored, friable, and silty. This rests on the Kansan drift at various depths, probably averaging less than 10 feet. In uncleared areas there is considerable organic matter in the surface 2 to 4 inches. In cultivated fields the content of organic matter is very low. The soil is shown by the litmus-paper test to be acid. Some lime concretions are occasionally encountered in the substrata, however, showing that the parent material was originally calcareous.

The Clinton silt loam occurs in the southern tier of townships along the Des Moines and Raccoon Rivers. The largest bodies lie north of the former river in Camp and Fourmile Townships. The topography is rolling, and the soil has weathered into its present state under conditions favorable to a rapid surface run-off. The elevation probably has a greater local range in this soil than in any other in the county, the highest margin of the soil being about 175 feet above the lowest. The divides are smooth and narrow, and where flat are occupied by the Tama soils. Drainage over the most of the type is good. Excessive washing occurs on some of the steeper slopes.

This soil is agriculturally rather important. The less rolling areas are nearly all under cultivation, but approximately one-half the type is used for pasture. Nearly all of this type was originally forested; at present less than a third of the total area is so occupied.

Wheat, corn, and oats are the important field crops, wheat being the main cash crop. Fruit growing with some trucking is important in the vicinity of Hastie. Several small commercial orchards are located in this locality. Apples and grapes do well with proper care. Potatoes do well on the newer soil, which contains considerable organic matter. Raising beef cattle is the important live-stock industry. Some of the largest cattle and horse pastures in the uplands are located on the rougher parts of this type. Dairying is not carried on extensively, except in those areas close to Des Moines.

Ordinarily winter wheat yields 18 to 25 bushels per acre. Little spring wheat is grown. Oats produce 35 to 40 bushels in normal

years and corn 20 to 30 bushels per acre. On the more rolling parts of the type the run-off is so rapid that not much water is absorbed or retained by the subsoil for midsummer use; hence in very dry summers the corn yields are greatly curtailed. The fact that considerable difficulty is experienced in growing alfalfa and clover satisfactorily is explained in large measure by the high acidity of the soil. Relatively more sorghum and millet are grown on this than on the other upland soils.

The Clinton silt loam is handled much as the Tama silt loam, though a definite system of rotating crops is seldom followed, and a much smaller acreage is devoted to tame hay crops than on that soil. Corn is usually planted with a lister. The soil is easily worked, but unless proper care is taken surface washing is quite active.

The selling price of the Clinton silt loam may, in exceptional cases, be as high as that of the Tama silt loam, but ordinarily prices range much lower. Topography, state of cultivation, location, and improvements all are factors determining the land values on this type.

Crop yields on the Clinton silt loam could be materially increased by applying lime to correct the acidity and by increasing the supply of organic matter. Barnyard manure and crop residues should be returned to the soil. Methods of cultivation that keep surface washing at a minimum are obviously necessary in managing the farms on this type.

BREMER LOAM.

To the depth of about 15 inches the Bremer loam is a dark-brown friable loam. This is underlain by a very dark brown silty clay loam which passes below 24 inches into a dark brownish gray, grayish-brown or brownish-gray silty clay loam. The clay content increases with depth. The lower subsoil may be quite compact in the more level areas, but over the type as a whole is fairly friable. The small areas near the mouth of the North River have considerable gritty material in the lower subsoil. A few areas, lying along the upper course of Beaver Creek, are probably Fargo loam, as the entire soil section is highly calcareous, but they are too small to be shown on the map.

The Bremer loam is similar to the Wabash loam in nearly all respects except its topographic position. In areas along the smaller streams the two are rather arbitrarily divided. Practically all of this type is developed in small areas along the rivers, Beaver and Walnut Creeks, and Jordan Branch. It occupies level to gently sloping benches in most places near their margins, from 2 to 5 feet above the general level of the overflowed bottom land at the base of slopes to higher lying sandy soils. In the latter position it often receives considerable surface wash from the higher land. Most of the soil

is above overflow, except during extreme flood stages, which are comparatively rare.

While not extensive, this is a rather important agricultural soil. Most of it is under cultivation. It has the same range of crop adaptation as the Bremer silty clay loam, and in general the same methods of farming are used. The yields ordinarily equal those on the heavier type. The loam is easier to handle and warms up earlier in the spring. Water does not stand on the surface for any great length of time. Early frosts do more damage than on the higher lying soils.

The Bremer loam is usually included in fields with adjacent bottom-land soils, and the selling price is the same as for those soils.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Bremer loam:

Mechanical analyses of Bremer loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332851	Soil	1.1	5.4	6.1	34.9	13.3	28.6	10.4
332852	Subsoil	.2	4.0	7.0	24.0	6.8	39.7	17.1

BREMER SILT LOAM.

The surface soil of the Bremer silt loam is a dark-brown to nearly black silt loam, high in organic matter. The subsoil, beginning at about 14 inches from the surface, is a dark-brown silty clay loam that grades gradually into a dark brownish gray to brownish-gray or grayish-brown silty clay loam in the lower part of the 3-foot section. The subsoil in general is friable, though it may be rather compact in local spots. Neither soil nor subsoil effervesces with hydrochloric acid. In some of the smaller areas there is little difference in color throughout the soil section.

Along Camp and Mud Creeks most of the type has a brownish-gray or mottled dark-brown and gray silty layer, 6 or 8 inches thick, in the upper subsoil. Otherwise the soil is the same as the typical.

The Bremer silt loam is developed along the lower course of the Des Moines River, along the Raccoon River, and along Camp and Mud Creeks. It lies on a bench from 5 to 15 feet above the present stream channels, where it is subject to overflow possibly once in 20 or 25 years. The surface is level or slopes gently toward the streams. The type has fairly good surface drainage and underdrainage. It is closely related to the Wabash silt loam and resembles that type in all respects, except that it lies at a slightly higher elevation. The line between the two is often rather arbitrarily placed.

The Bremer silt loam is one of the important bottom-land soils of the county. It is very productive and is highly esteemed by the farmers. It is practically all under cultivation, corn, wheat, oats, and hay being the principal crops. Yields are much the same as on the closely associated type, the Bremer silty clay loam. Some sweet corn is produced on a commercial scale in the vicinity of Des Moines.

This soil is friable and is easily cultivated. As a rule it requires less draft power than the silty clay loam, but in adjacent areas there is little difference in that respect. The selling price is about the same as for the heavier soil.

BREMER SILTY CLAY LOAM.

The Bremer silty clay loam is a dark-brown to nearly black silty clay loam grading at about 18 inches into a dark-brown to dark brownish gray, rather tough clay. There is seldom a distinct division between the soil and subsoil, the clay content increasing gradually with depth. The surface soil is high in organic matter and usually friable in the surface 6 inches. The subsoil contains numerous rusty-brown iron stains. Neither soil nor subsoil contains enough lime to effervesce with hydrochloric acid.

The boundary lines between this soil and the silt loam or the loam are in places arbitrarily drawn, on account of similarity of texture. Small spots of loam occur within the silty clay areas, having resulted through deposits of surface wash in places near the sandier upland soils. Adjoining the Bremer clay and in the poorer drained areas the soil section often has a higher clay content and the subsoil may be nearly black, dense clay. This is especially true in the areas west of the Skunk River and southwest of Saylorville. In the areas near Loring the lower subsoil is brownish gray to drab colored in most places. The higher lying parts of the type in this vicinity may have a brown to brownish-yellow or grayish-yellow clay in the lower depths. Areas along the smaller streams may have considerable grit in the lower subsoil, and a few small areas, less than 200 acres in total extent, lying along the upper course of Beaver Creek are highly calcareous throughout the soil section and the lower subsoil has a yellowish to grayish cast. The soil in these areas is more properly Fargo, and the areas are included with the Bremer because of their small extent. Near the breaks to lower lying soils the subsoil may be grayish brown in color. In the area in sec. 3, T. 81 N., R. 22 W., the soil is underlain at about 30 inches by a layer of coarse sand and gravel.

The Bremer silty clay loam is derived chiefly from glacial drift that was reworked by running water and deposited at the close of the glacial period. Except in topographic position it differs but little from the Wabash silty clay loam, and is geologically but little

older. It occurs on the lowest of the second bottoms along the larger streams, but practically all of it is above the reach of ordinary floods in these streams, though it may receive considerable drainage from the adjacent hills in rainy seasons. Parts of this type are said to have been inundated once or twice during the last 40 years. Along the Des Moines River the terrace level is from 10 to 15 feet above the present stream beds. Along the Skunk River and bordering the creeks it is from 2 to 10 feet above the overflow land, and the slope in places is so gradual as to be almost imperceptible to the eye. The largest areas lie along the Skunk River and along the Des Moines River in the southern part of the county. Some of these are long narrow strips; others are large regular-shaped bodies covering as much as 1 square mile. A number of small, narrow belts have been developed along Beaver and Walnut Creeks and the creeks in the southeastern part of the county.

The surface of the Bremer silty clay loam is nearly level or slopes very gently toward the streams. The areas for a few rods from the base of the hills along the south side of the Skunk River have the appearance of very gradual foot slopes. Drainage as a whole is fair, but is slow in some of the more level areas, and ditches are used to carry off the surface water. Internal drainage is improved in some of these areas by the use of tile systems.

With the exception of land occupied by a few small pastures, the farmsteads, and towns, the Bremer silty clay loam is practically all under cultivation, the type being one of the most valuable bottom-land soils of the county. It was originally partly forest and partly prairie. The tree growth consisted chiefly of oak, elm, walnut, and hickory, with some brushy undergrowth.

The most important crops, in the order of their importance, are corn, oats, wheat, and hay. The chief live-stock industries are the growing of hogs and the feeding and fattening of beef cattle. The summer pasturing of cattle is usually done on adjacent lower lying types along the streams. Cattle are shipped in annually and fed on the products of this soil and the lower lying soils along the Skunk River. Some dairying is done near Des Moines, the herds being of good quality. Some of the soil along the Skunk River is devoted to sweet-corn growing.

Grain yields are ordinarily about the same as on the Carrington loam, except that wheat may give a slightly greater return and relatively more of this soil is devoted to this crop. Clover and timothy produce as well or better than on the Carrington. Alfalfa has been tried by very few.

The Bremer silty clay loam is handled much the same as the Carrington loam. The friable nature of the surface few inches makes it easier to cultivate than the Webster silty clay loam, but

heavy farm equipment is required nevertheless. The more level areas are slow to warm up in the spring, and some difficulty is experienced in the summer cultivation of crops in wet seasons. The even surface permits the use of tractors to good advantage. The soil breaks down thoroughly when plowed under proper moisture conditions, but if plowed when too wet it is likely to bake. Surface cracking is common in dry seasons. Early frosts are likely to do more damage than on higher lying soils.

Land of the Bremer silty clay loam sells for $200 to $225 an acre.

BREMER CLAY.

The Bremer clay consists of a nearly black crumbly clay about 18 inches deep, resting on a subsoil composed of very dark brown compact clay in the upper parts and grading downward into a dark brownish gray to brownish-gray clay. Locally the entire soil section is dark colored and the demarcation between the soil and subsoil indefinite. The subsoil in the larger areas may contain considerable grit in the lower depths. In a few of the smaller areas the lower subsoil may have a pale-yellow cast. The surface soil is high in organic matter. Neither soil nor subsoil contains lime enough to effervesce with hydrochloric acid.

This soil is comparatively inextensive in Polk County, though the largest area, occurring south of Saylorville, embraces about 1 square mile. Small bodies occur on the more level stretches of low-lying second bottom along Walnut Creek, the lower course of the Des Moines River, and Skunk River. The surface is level and the drainage poor. Ditches and tile drains are used in some of the areas. The origin of the soil is the same as that of the closely associated type, the Bremer silty clay loam, but deposition in case of this heavier type was probably made under standing water. It lies above the ordinary floods, but may receive considerable run-off from higher lying soils. The original growth was composed chiefly of slough grass.

Most of the small areas of Bremer clay are under cultivation. They are devoted to the same crops, with the same relative importance and similar yields, as the Bremer silty clay loam. This soil is somewhat intractable, and heavy draft power is required. The type is one of the last in the county to warm up in the spring, and, unless very well drained, corn planting is greatly retarded. It clods badly when plowed too wet and bakes and cracks upon drying.

A part of the larger areas is kept in the native grasses and used for the production of hay and for pasture. Hay yields about 1½ tons to the acre annually. The usual selling price of the Bremer clay is about the same as that of the silty clay loam.

The following table gives the results of mechanical analyses of samples of the soil and subsoil of the Bremer clay:

Mechanical analyses of Bremer clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332840	Soil	0.1	2.6	5.0	10.7	8.0	43.9	29.1
332841	Subsoil	.0	1.8	2.3	15.2	7.2	29.6	43.1

CHARITON SILT LOAM.

The Chariton silt loam is very inextensive in Polk County. Only six small areas are mapped, with a total area of approximately 200 acres. The surface soil is a dark-gray to dark grayish brown, smooth silt loam. The subsoil from about 9 to 20 inches is a gray to light-gray ashy silt loam. The lower subsoil is a drab-colored, impervious clay, slightly mottled with brown. The surface soil is only moderately high in organic matter. The lower subsoil is marked with numerous reddish-brown iron stains. In a part of the largest area in sec. 1, T. 79 N., R. 25 W., the subsoil shows some reddish-yellow mottlings in the lower depths. In the smaller areas in this section the surface soil varies from a loam to a heavy fine sandy loam.

The Chariton silt loam is developed on the high river terraces as low-lying, poorly drained areas within areas of the Bremer or Waukesha soils. Underdrainage is very poor on account of the impervious nature of the subsoil. The soil occurs above overflow, but water stands on the surface for a considerable period after heavy rains unless the land is ditched. Three small areas of the type lie immediately south of Camp Dodge and three others southeast of Avon Station.

The type was originally prairie, and part of it still remains in grass and is used for pasture. The chief grasses are bluegrass and redtop. On the cultivated areas corn, oats, and wheat are grown, with fair yields in normal seasons.

The Chariton silt loam is farmed with the adjacent soils and the cultural methods are similar to the methods used on those types.

BUCKNER FINE SANDY LOAM.

The surface soil of the Buckner fine sandy loam is a dark-brown fine sandy loam. The subsoil, beginning at depths ranging from 12 to 18 inches, is a dark-brown to yellowish-brown fine sandy loam, which normally is quite loose and incoherent in the lower part of the 3-foot section. The content of organic matter is moderately high in

the low-lying areas, but in the higher areas is lower, especially in fields that have been cultivated for any great length of time. Only in rare cases does the soil section contain any gravel or bowlders.

The Buckner fine sandy loam occurs chiefly in two sections of the county, one to the north of the Skunk River and one along Beaver Creek. A few small bodies are along the Des Moines River, some south of Marquisville, one east of Walnut Creek, and one west of Polk. The soil occupies two general levels on the high terraces. The lower level is but 5 or 10 feet above the first-bottom soils and may overflow in seasons of extremely high floods. These areas are in the minority, usually small, and have a nearly level surface. Most of them are situated next to the first-bottom soils along the Skunk River. The areas of higher level lie from 10 to 25 feet above the overflow land. Here the soil occupies minor elevations and benches with a nearly level to gently undulating surface. Over the whole occurrence of the soil the surface drainage is good, and the internal drainage is rarely, if ever, excessive.

This soil is naturally productive and can easily be kept so under careful management. It warms up early in the spring, and crops rarely suffer from drought. Probably 85 per cent of it is under cultivation and devoted chiefly to the growing of corn, oats, and wheat. These crops give good yields. Good results also are obtained with watermelons, cantaloupes, sweet potatoes, cucumbers, and tomatoes, but they are usually grown for home use only.

A part of the type is used for pasture, the sods consisting of the native prairie grasses and some bluegrass. Land of this type ordinarily sells for $150 to $225 an acre, depending upon the state of cultivation, the location, and improvements.

The application of barnyard manure and the growing of more leguminous crops would benefit most of this soil.

O'NEILL FINE SAND.

The O'Neill fine sand is not an extensive soil in Polk County. It consists of a grayish-brown to brown fine sand which gradually becomes yellowish brown in the lower depths of the 3-foot section. The surface 6 inches may contain considerable organic matter, and as a result have a dark grayish brown color in areas which have not been cultivated.

Most of the O'Neill fine sand occurs on narrow minor elevations on the eastern edges of the overflow land along the Skunk River and Indian Creek and as low mounds in the areas of first bottoms. The areas rise from 5 to 15 feet above the surrounding soils. The surface is flat and in a few cases dunelike. The surface soil is inclined to blow to some extent, where not kept in cover crops. Internal drainage

through the loose, porous soil material is rapid. Four other small areas are mapped with this soil because of their small extent; one is north of Polk, one north of Andrews, a third south of Berwick, and the other south of Peoria City. These areas are gravel-pit residues, and consist of a mixture of gravel, coarse sand, and some clay. They are of practically no use agriculturally except for the scant pasturage they offer.

The O'Neill fine sand is not an important soil. Much of it supports a sparse growth of native prairie grasses and is used as pasture. The remainder is occupied by farmsteads or cultivated in fields with adjacent soils. Corn yields are usually unsatisfactory, and the small grains ordinarily yield less than on the adjacent soils. Some vegetables are produced for home use with good results. The most important need of this soil is organic matter.

O'NEILL FINE SANDY LOAM.

The surface soil of the typical O'Neill fine sandy loam is a dark-brown to dark grayish brown fine sandy loam, 12 or 15 inches deep. The subsoil is a dark-brown to brown fine sandy loam, grading at about 27 inches into a lighter colored sand which overlies a basal stratum of gravel and sand. The surface soil is moderately high in organic matter. Soil and subsoil are normally free of gravel, but in a few small areas along the upper course of the Des Moines River, along Beaver Creek west of Camp Dodge, and on Big, Fourmile, and Indian Creeks the loose substratum in the 3-foot section is a mixture of gravel and coarse sand, and occasionally gravel is found throughout the soil section.

The O'Neill fine sandy loam is developed on the highest second-bottom lands, or terraces, along the Des Moines River and its larger tributaries from Des Moines north and on Indian Creek. One other area occurs at Avon Station. These terraces are developed from the Wisconsin gravel train. They are practically all above overflow. With the exception of the areas at Johnston and Avon Station the soil occurs in narrow disconnected belts. The surface is usually gently undulating to sloping or level. Surface drainage is not well developed and most of the water sinks through the soil. The porous subsoil is not very retentive of moisture. Where the soil is not kept in a high state of cultivation the field crops on it are usually the first to suffer in dry seasons.

The O'Neill fine sandy loam is a rather important soil in this county. Probably 70 per cent of it is under cultivation; some of the smaller areas are used for pasture. The native grasses make a rather thin sod. Where cultivated the chief field crops are corn, wheat, and oats. The soil is handled much the same as the adjacent terrace

soils. The more successful farmers grow small grains in preference to corn. Crop yields vary considerably with the season and with the water-holding capacity of the soil from place to place. The yield of corn is usually lower than on the O'Neill loam. In the spots where the water-holding capacity of the soil is highest the crop yields may average as high as on that soil.

On the areas of this soil near Avon Station, close to Johnston, and immediately north of Des Moines truck growing is a very important industry. The soil when used for trucking is kept in a high state of cultivation. Large quantities of barnyard manure are applied annually. The soil is highly esteemed for trucking, early crops doing exceptionally well. Late crops produce large yields of good quality unless prolonged droughts occur. Good results are obtained with watermelons, cantaloupes, sweet potatoes, cucumbers, tomatoes, and cabbage. Early sweet corn does well, but late plantings are usually not as satisfactory.

The O'Neill fine sandy loam in the smaller areas is generally sold in farms with the adjacent types. In the larger areas, where the location and the condition of the soil is suitable for the growing of truck crops, it is usually priced at $200 to $250 an acre. Where used for general farm crops and pasture the average price is lower.

Over the most of the type there is a deficiency of organic matter and the need for applications of animal or green manures is great. Increasing the content of organic matter will aid the soil materially in retaining moisture.

The following table gives the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the O'Neill fine sandy loam:

Mechanical analyses of O'Neill fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
332817	Soil	0.0	1.1	4.0	57.0	9.6	17.7	10.3
332818	Subsoil	.0	.7	3.3	59.5	11.7	15.6	9.8
332819	Lower subsoil	.0	.7	3.7	65.9	10.5	14.5	4.6

O'NEILL LOAM.

The surface soil of the O'Neill loam is a dark-brown to dark grayish brown loam about 10 inches deep. The subsoil from 10 to about 24 inches is a brown loam to light silty clay loam which gradually becomes sandier with depth and is underlain by a coarse stratum consisting chiefly of gravel, coarse sand, and in places small bowlders. The surface soil is ordinarily moderately high in organic matter.

It may be light textured in the more undulating areas, or, on the other hand, quite silty, as in the flatter areas. In places the supply of organic matter is deficient, and the soil when dry is brown in color. Considerable coarse sand and gravel frequently occur on the surface and through the soil section. Neither soil nor subsoil contains enough lime to effervesce with hydrochloric acid. The substratum of coarse material is usually free from clay, except in the upper few inches. In a few areas near Johnston and Avon Station the substratum, composed of sand, extends upward into the 3-foot section.

The O'Neill loam occurs as small disconnected areas, along the Des Moines River above the mouth of the North River, along the larger creeks in the western part of the county, and along Indian Creek. No area includes over 200 acres. It lies on high terraces, from 10 to 40 feet above the overflowed bottoms. The soil has been formed from the Wisconsin gravel train as deposits from swift glacial streams, and the later surface covering of finer material has been accumulated both by the agency of wind and of water.

The surface of this soil is nearly level to gently undulating. Surface drainage is good, except in the flatter areas, where most of the surface water escapes through the subsurface layers. Where the coarse substratum lies near the surface internal drainage is inclined to be excessive, but over the most of the type the surface soil and upper subsoil are fairly retentive of moisture. The type as a whole, however, is not as retentive as the Bremer and Waukesha soils, and in years of prolonged dry spells during the growing season crops are apt to suffer.

Comparatively speaking, the O'Neill loam is not an extensive or important agricultural soil. Originally it supported a prairie vegetation. Practically all of the larger areas are under cultivation, but many of the smaller ones are used for pasture.

The crops grown on this soil and the methods of farming are much the same as on the Waukesha loam. In favorable years the yields on the two are about the same, but where the soil is thin, or the fertility has been decreased by poor farming methods, the yields on this soil will not average as high in exceedingly dry years as on the Waukesha soil.

Land of the O'Neill loam is usually sold in farms with adjacent soils.

WAUKESHA LOAM.

The Waukesha loam is similar to the Carrington loam except for its topographic position. It differs from the O'Neill loam in not having a substratum of sand and gravel in the 3-foot section. The type consists of a dark-brown, friable loam about 15 inches deep,

containing a moderate amount of organic matter, underlain by a brown heavy loam which passes quickly into a brown to yellowish-brown or brownish-yellow, friable silty clay loam. The color of the surface soil on breaks to streams is usually lighter than typical, while on the more level portions of the type it is darker. Its texture is quite uniform over the whole county, though local variations may occur adjacent to other soils. An occasional glacial gravel or pebble is encountered on the surface and through the soil section. As a rule, neither the soil nor subsoil contains enough lime to give a reaction with hydrochloric acid.

The basal material of the Waukesha loam along the present channel of the Des Moines River from Des Moines north, and of most of that along its pre-Wisconsin channel, is undoubtedly composed of coarse material quite similar to the substratum of the O'Neill loam, at depths averaging from 4 to 10 feet. Over the remainder of the county the basal material is probably bowlder clay of the Wisconsin and Kansan drift sheets. The areas in the southern part of the county are derived in part from silty material. The subsoil in most of the areas has a rather compact structure, but in much of the higher lying soil north of the Skunk River and west of Beaver Creek near Johnston it is open and very friable. There does not seem to be much difference in the productiveness as a result of this variation. In the area to the west of Beaver Creek, just mentioned, small areas or spots of soil on the breaks to the smaller drainageways resemble the Shelby loam in cross section. These are not extensive. In sec. 3, T. 81 N., R. 22 W., the surface soil is quite heavy, approaching a silty clay loam, and the subsoil is a dark yellowish brown silty clay loam which becomes lighter colored and more compact with depth.

The Waukesha loam occupies narrow terraces or high benchlike areas along the streams in all parts of the county. Along the smaller creeks the terraces usually lie from 5 to 10 feet above the level of the first bottoms; along the larger creeks and rivers they may rise to levels as high as 40 feet above the overflow land. The surface of the Waukesha loam varies from flat to gently undulating or sloping. The older areas, especially to the west of Beaver Creek, are in some places considerably dissected, but over the most of the type erosion is not active. The only well-established drainage lines are those issuing from the adjacent uplands. The general slope of the surface is usually enough to insure good drainage. The subsoil retains moisture well and the soil withstands droughts over long periods.

The Waukesha loam is the most extensive high-terrace soil in the county, and is very important in the local agriculture. Approximately 85 per cent of it is under cultivation, a small proportion being occupied by towns and farmsteads or used for pasture. The soil supports a good sod of prairie grasses and bluegrass. The most im-

portant grain crops are corn, oats, and wheat, corn being the principal cash crop. Hog raising and the raising and feeding of beef cattle are the most important live-stock industries. The cattle are usually pastured on adjacent lower-lying soils during the summer months. Cattle are fattened in feed lots, the ration combining hay with corn and other concentrates. Cattle are shipped in and fattened on this soil along the Skunk River. Dairying is done on a small scale in areas on the interurban lines and near the city. Some sweet corn is grown in the northeastern part of the county for the canning factories. Fruit is produced with moderate success on this soil, but usually for home use only.

Corn yields on this soil will average 35 to 40 bushels per acre, oats 35 to 45 bushels, winter wheat 20 to 27 bushels, and spring wheat 18 to 21 bushels. More wheat is grown in proportion to other crops than on the Carrington loam. This crop is said to withstand hard winters better on this soil than on most of the upland soils. Of the hay crops, clover and timothy mixed ordinarily produce 1½ tons per acre, clover alone 1½ to 1¾ tons, and timothy alone 1¼ to 1½ tons. The acreage of the hay crops is being gradually extended. Alfalfa has not been produced on a large scale, but results on most of the small areas have been promising.

The Waukesha loam is handled much the same as the Carrington loam. It is easy to cultivate on account of its favorable topography and good structure. Farm tractors are coming into common use. The general tendency at present is to grow more hay crops and more wheat and to improve the soil by the systematic rotation of crops. Not enough barnyard manure is produced on the average farm to make an application to the soil as often as most farmers desire.

The Waukesha loam ordinarily brings from $200 to $225 an acre, the price depending chiefly upon the location and the improvements.

WAUKESHA SILT LOAM.

The surface soil of the Waukesha silt loam is a dark-brown to nearly black, smooth silt loam, about 14 inches deep. The subsoil is a yellowish-brown to brownish-yellow, rather compact, heavy silt loam to light silty clay loam, the clay content increasing with depth. The surface soil is moderately high in organic matter. A few of the smaller areas, lying adjacent to the Clinton silt loam in the southeastern part of the county, have a shallow layer of dark-gray silt loam on the surface, and over the more level portions of the area southwest of Runnells the soil is heavier than typical, the clay content in some places being great enough to form a silty clay loam. Elsewhere the entire soil section is remarkably uniform. The type is quite free from coarse material.

The Waukesha silt loam is derived from silty material. Its most common occurrence is in the southern fourth of the county on high terraces along the Des Moines River and its tributaries. Four areas ranging in size from 80 to 300 acres occur in the northern part of the county on the flatter parts of the high benches along the Des Moines and Skunk Rivers; one is west and one south of Polk, one is west of Johnston, and the fourth is 3 miles northwest of Santiago. The terraces occupied by the type are from 10 to 40 feet above the stream channels and are not subject to overflow. The surface of the soil is flat to gently sloping. Drainage is good.

Practically all of the Waukesha silt loam is under cultivation. The same crops, ranking in the same order of importance, are grown as on the Waukesha loam; namely, corn, oats, and wheat. Crop yields do not differ materially from those obtained on that type. The type is handled much the same as the Waukesha loam and the selling price is quite similar.

The Waukesha silt loam is friable and is easily cultivated under a wide range of moisture conditions. It seldom bakes or cracks, and is naturally retentive of moisture and resistant to drought.

LAMOURE SILTY CLAY LOAM.

The surface soil of the Lamoure silty clay loam is a very dark brown to nearly black silty clay loam, high in organic matter. The subsoil, beginning at about 20 inches, consists of a dark-drab clay which becomes lighter colored with increasing depth. In the smaller areas the lower subsoil may contain some coarse sand and have a yellowish cast. Brown to reddish-brown iron stains occur in the lower subsoil in the better drained areas. Both soil and subsoil are highly calcareous, the lime occurring as small particles. Near the center of the larger areas the surface soil may be very heavy textured. This is especially true along Beaver Creek. On the other hand, parts of the type lying adjacent to higher lying sandy soils may have a surface covering that is distinctly loamy.

The Lamoure silty clay loam has been formed from reworked glacial drift material laid down in slowly moving or stagnant water. It is developed along the creeks and smaller drainageways in the northern three-fourths of the county. It occurs as narrow strips along low-gradient streams, as larger bodies lying back from the stream channels in the larger creek bottoms, and as old lake beds or sloughs, recently drained. The surface is level and the drainage naturally poor. Unless the land is properly ditched or tile drained, water often stands on the surface for some time after heavy rains. Near most of the stream channels the type is subject to annual overflow.

Although not extensive, the Lamoure silty clay loam is a rather important farming soil. About half of it remains in the native slough grasses, usually of the finer leaved varieties, and is used mostly for pasture. Practically all the rest of the type has been drained, both with open ditches and tile, and is devoted chiefly to the production of corn. There are small acreages in small grains, but they are inclined to grow too rank in wet seasons. A very little land is in cultivated grasses. The feeding of beef cattle is the principal livestock industry. On well-drained land corn yields, in normal years, 40 to 50 bushels per acre. Slough grass ordinarily yields 1 to 1½ tons of hay per acre.

The Lamoure silty clay loam requires as heavy tillage implements and draft power as the Webster clay loam, but the high content of organic matter tends to prevent the formation of clods and a good tilth can be maintained with careful handling. The soil is inclined to bake and crack in dry seasons, but not as badly as the Webster clay loam. Corn is grown on the same land several years in succession, and very little attempt has been made to rotate crops according to any definite plan. Little or no manure is applied.

Land of the Lamoure silty clay loam is usually included in fields with the adjoining types. Where well drained, its selling value is about the same as that of the Bremer silty clay loam.

WABASH FINE SANDY LOAM.

The soil of the Wabash fine sandy loam consists of a dark-brown fine sandy loam which becomes more compact and lighter colored in the lower depths of the 36-inch section. The surface soil is moderately high in organic matter. The lower subsoil may be dark brownish gray or brownish gray in color. The entire soil section is quite friable. One or two small areas along the channel of Skunk River are composed of a gray to dark-gray fine sand, 8 to 12 inches deep, overlying the typical Wabash clay.

Practically all of the Wabash fine sandy loam is developed in small areas in the Skunk River bottoms. It usually occurs as recent wash along drainageways issuing from higher lying sandy soils. Owing to the generally sloping surface and the porous nature of the soil material, drainage is good. Unless diked or ditched this soil may overflow with more or less frequency, but water rarely stays on the surface long enough to damage the crops seriously.

The Wabash fine sandy loam is not an important soil in this county because of its small area. Corn is the principal crop. It ordinarily yields 35 to 50 bushels per acre.

This soil is handled in much the same way as the Buckner fine sandy loam. Little manure is applied. The land warms up early in

the spring and can be worked under a wide range of moisture conditions. The type is retentive of moisture, and crops are seldom affected by drought.

The Wabash fine sandy loam is farmed in fields with the adjacent soils.

WABASH LOAM.

The Wabash loam consists of a dark-brown to nearly black mellow loam about 18 inches deep. The subsoil is a dark-brown to dark brownish gray silty clay loam, the clay content increasing and the color becoming lighter with depth. The surface soil is quite high in organic matter. Neither soil nor subsoil contains enough lime to effervesce with hydrochloric acid. In places there is but little perceptible difference throughout the 3-foot section, the material being a dark-colored loam, but in most of the area the subsoil is more compact than the surface soil. The surface soil is quite variable within certain limits, usually being heavier in the lower lying parts of the type back from the stream channels, and sandier near the banks where it is most frequently overflowed. In some of the very narrow stream bottoms the surface soil may pass from a fine sandy loam to a heavy loam in short distances.

The Wabash loam is most extensively developed along the creeks in the glacial-drift region of the county and along the North River. Here it occurs as long strips ranging in width from a few hundred feet to a quarter of a mile, and may occupy all, or nearly all, of the bottom lands subject to annual overflow. A few small areas occur along the rivers, and these occupying fairly high positions are subject to less frequent overflow than the rest of the type.

The surface of the Wabash loam is flat, but drainage is fair, owing to the presence of many old channels and sloughs which carry off the excess water.

Less than 20 per cent of the Wabash loam is under cultivation. Most of the type along the creeks is used in the production of hay or for pasture, overflows rendering the production of cultivated crops too uncertain. The small areas in the river bottoms and some of the wider areas along Fourmile, Walnut, and Big Creeks are planted to crops, chiefly corn, oats, and wheat. Along the stream channels considerable belts of timber, consisting mainly of oak, elm, locust, hickory, black walnut, and cottonwood, occur.

On the Wabash loam which is well drained and lying above frequent overflow corn yields 40 to 45 bushels per acre, wheat 20 to 25 bushels, and oats 35 to 45 bushels. Corn is grown several years in succession. The proportion of the cultivated area in grain is less than on the higher lying soils, because these crops grow too rank and lodge in wet seasons. The acreage in tame grass is smaller.

Wild grasses yield 1 to 1½ tons of hay per acre. Nearly all of the grassland is used for pasture.

The Wabash loam is a strong, productive soil. It can be worked under a wider range of moisture conditions than the heavier types of the series and warms up earlier in the spring. It turns up mellow from the plow. Little or no manure is used on this type. The soil is usually farmed in fields with, and handled much the same as the adjacent soils.

Well-drained areas large enough to farm in separate fields bring $150 to $225 an acre, depending chiefly upon the frequency of overflow, the location, and to what extent the land is cut by streams, sloughs, and abandoned channels.

WABASH SILT LOAM.

The Wabash silt loam, to the depth of about 18 inches, consists of a dark-brown to nearly black loam, high in organic matter. Underlying this is a very dark brown silty clay loam, which gradually becomes brownish gray in the lower depths of the 3-foot section. The change in color and texture from surface soil to subsoil is very gradual, and in places imperceptible. In areas adjacent to the Clinton silt loam the surface may have a shallow covering of lighter colored silty material. In the small areas lying about 2 miles east of Avon Station the surface soil is shallower than typical, and the subsoil, in the lower depths, is dark yellowish brown.

All the Wabash silt loam occurs in the silt-covered region in the southern part of the county. It is developed mainly in long narrow strips, varying from a few rods to one-seventh of a mile in width, and it covers nearly the whole of the first bottoms along the lower courses of Camp, Mud, Spring, and Yeader Creeks. Other smaller strips lie along the smaller creeks near Commerce, and a few small areas occur to the east of Avon and south of Adelphi in the Des Moines River flood plain. Practically all of the type is subject to annual overflow, except the areas in the Des Moines River bottoms. These areas are higher lying and seldom overflowed, and even when this does occur the flood waters do not stay on them long enough seriously to injure growing crops. The surface of the type, while as a whole nearly flat, is interrupted in many places by old stream channels. The drainage in general is rather poor.

The Wabash silt loam is relatively inextensive. The areas along the larger bottoms are farmed, but nearly all the rest of the type is still in the native grasses and forest, and is used for pasture.

On the cultivated parts of the type corn, oats, and wheat are the principal crops. Approximately the same yields are obtained as on the Wabash loam. The farming methods also are much the same on this soil as on the loam, and the selling values are similar.

The Wabash silt loam is naturally productive. Where well drained it can be handled as easily as the Tama silt loam; in fact it can be tilled under a wider range of moisture conditions, as the organic content of the soil is higher and the tendency to clod is less marked.

WABASH SILTY CLAY LOAM.

The surface soil of the Wabash silty clay loam is a very dark brown to nearly black silty clay loam, high in organic matter. The subsoil, which begins at about 18 inches, is typically a dark-brown or dark brownish gray, rather compact clay loam or clay, but in many places in the lower part is brownish gray or drab, and marked with numerous reddish-brown iron stains. Along the channels of the Skunk River the surface soil may contain considerable sand as the result of surface wash, otherwise the soil, as a whole, is uniform.

The Wabash silty clay loam reaches its greatest development along the Skunk River and Indian Creek and along the Des Moines River below Des Moines. On the last-named stream the type occupies a position intermediate between the Bremer and the Sarpy soils, lying slightly above the latter and about 5 feet below the former. These areas overflow only at very high flood stages. Along the Skunk River the type usually lies as narrow strips along the channels and near the outer margins of the overflow land, on a level or but little higher than that of the Wabash clay. Here overflow is more or less frequent.

The surface of this soil is flat. Drainage is slow, both on account of the nearly level topography and the heavy, compact subsoil. Water stands on the surface of the flatter areas for some time after heavy rains or inundations.

Most of the Wabash silty clay loam is under cultivation. On the better drained areas the same crops are grown as on the Wabash loam. These crops have the same relative importance as on the latter soil, and the yields obtained are as good. The uncultivated area is in native grasses and is used for pasture and hay land.

The Wabash silty clay loam is more difficult to handle than the Wabash loam, but is more friable than the clay. It does not bake and crack as badly as the last-named soil, but care must be taken not to plow it when too wet, as clods form readily and, unless broken down immediately after turning, become hard and difficult to pulverize in subsequent cultivation. Heavy draft power is needed for tillage operations. The silty clay loam is not as early a soil as the loam.

The price of land of the Wabash silty clay loam ranges from $160 to $225 an acre, varying with the location, the drainage conditions, and the frequency of overflow.

WABASH CLAY.

The soil of the Wabash clay consists of a very dark brown to nearly black clay containing much organic matter. The line between the soil and subsoil is very indistinct, but the material gradually becomes lighter colored and more plastic with increasing depth. The lower subsoil is usually a dark brownish gray, but may be drab colored in the smaller areas. It is splotched with numerous iron stains. A small amount of sand may occur throughout the body of the soil, and near the stream channels a layer of sand 2 or 3 inches deep may cover the surface. In some of the narrower strips along the Des Moines River the soil may be lighter colored than typical and be underlain below the 30-inch depth by a layer of sand.

The Wabash clay is the most extensive alluvial soil in the county and over 90 per cent of it is developed along the Skunk River. Other areas are mapped in the first bottoms of the Des Moines River near the mouths of Beaver and Fourmile Creeks and along old channels and depressions in the vicinity of Adelphi and Levey. Small areas lie along Indian Creek and the Raccoon River. Along the Skunk River the soil occupies practically the whole of the first bottoms, while in the other areas it occurs as elongated, narrow bodies.

The surface of the Wabash clay is flat. With the exception of the area near the mouth of Fourmile Creek, it occupies the lower lying bottoms and is subject to overflow nearly every year. The excepted area, although lying on the flood plain of the creek, is seldom overflowed in its entirety. Drainage of the type as a whole is poor. The Skunk River has been straightened and some small drainage ditches have been constructed in all of the areas of the type, but their carrying capacity is generally not sufficient to remove the water fast enough. An improvement has been made, but there is need for larger and more numerous lateral ditches and possibly some dikes, especially along the Skunk River. Water often stands on the surface after each overflow or heavy rain, and in the lower parts of the type the soil is more or less marshy.

Chiefly because of unfavorable drainage conditions, less than 40 per cent of the type has been put under cultivation. Along the Skunk River much of the acreage of this soil upon which crops are destroyed by flood waters too late for replanting with corn is allowed to stand idle for the rest of the season. Some belts of forest consisting of oak and elm occupy the stream banks, but the greater part of the uncultivated land supports a luxuriant growth of slough grasses and is used in the production of hay and as pasture land. Some of the largest pastures in the county are located on this type. Corn occupies the larger part of the cultivated area. Wheat and oats are the crops of secondary importance. The leading live-stock industry is the feeding of beef cattle.

Corn and wheat produce well in seasons of normal rainfall. Under favorable conditions the former yields from 40 to 70 bushels and wheat 20 to 30 bushels per acre. Ordinarily slough grass produces from 1 to 2 tons per acre. Hay of the finer leaved varieties of grass is fed to live stock; that from the coarser is baled and sold for packing. About 30 per cent of the area in slough grass is cut for hay; the rest is pastured. Considerable sweet corn has been grown on this soil along the Skunk River in recent years, the product going to the canning factories. This crop is very popular, especially in years when spring is backward or when floods come so late as to make the replanting of field corn impracticable. The yield of sweet corn ranges from 3 to 5 tons of ears per acre.

The Wabash clay is one of the most difficult soils in the county to handle. It can be properly cultivated only under a very narrow range of moisture conditions, is very sticky when wet, and cracks upon drying. If plowed when too wet it clods and bakes, and when dry it is difficult to break at all. When worked in a fairly moist condition, however, a mellow tilth can be prepared and maintained. Disking the land before plowing has given good results, causing the soil to turn easier and to break up into a better tilth. Five or six horse teams or tractors are used in tillage operations.

The Wabash clay is a very productive soil and its fertility has apparently been but little impaired even in the fields most continuously planted to one crop. Land values range from $140 to $200 an acre, depending chiefly upon drainage conditions and location.

SARPY FINE SANDY LOAM.

The soil section of the Sarpy fine sandy loam is quite variable in texture. The surface soil in most places consists of a grayish-brown to brownish-gray fine sandy loam or loamy fine sand. At an average depth of 14 inches this rests upon a grayish-brown, heavy fine sandy loam, which becomes lighter in color and texture at about 27 inches and passes into a light grayish brown loamy fine sand or fine sand. In places considerable coarse sand and fine gravel occur throughout the soil section. The surface soil is low in organic matter.

The Sarpy fine sandy loam is not very extensive in this county. It occurs in small isolated areas along the Des Moines and Raccoon Rivers, where it lies from 5 to 15 feet above the normal level of the streams. The surface is flat and drainage good, most of the water percolating downward through the loose, porous soil. It is subject to overflow.

Most of this type is in cultivation, being included in fields with other soils. Corn and sorghum are the important crops. Yields as good as those obtained on the Sarpy very fine sandy loam are produced on the heavier textured parts of this type, but on most of the

soil they are much less, especially in dry seasons. Most of the uncultivated area of this soil supports a sparse growth of grass, cocklebur, and sandbur, or is bare of vegetation.

SARPY VERY FINE SANDY LOAM.

To a depth of about 27 inches the Sarpy very fine sandy loam consists of a grayish-brown to brownish-gray very fine sandy loam. This rests on a brownish-gray to gray very fine sand practically free from clay. The soil is low in organic matter, though the surface 12 or 15 inches may contain a larger percentage than the lower soil, especially in areas that have not been cultivated. On the crests of some of the minor elevations the surface 8 or 10 inches may be composed of a very fine sand. The soil material through the section is calcareous.

The Sarpy very fine sandy loam lies along the Des Moines and Raccoon Rivers. It reaches its greatest development as strips ranging in width from a few rods to half a mile along the channels in bends of the streams. The surface of the soil is billowy, or gently undulating, and the land is well drained. This soil lies from 5 to 15 feet above the bed of the streams. Unless diked, it is subject to more or less frequent overflow, depending upon the elevation. After the floods subside, however, the surface soil dries out quickly.

Much of the Sarpy very fine sandy loam supports a growth of forest, chiefly oak, elm, ash, walnut, cottonwood, and willow. Some grass grows in these forested areas, but the growth is not as heavy as on the heavier soils. This land is used for pasture. Where the soil is cultivated the chief crop is corn, followed in importance by oats and wheat. These crops give fairly good yields in normal years. Some sorghum is grown.

The higher parts of this soil are highly prized for the production of truck crops, both for home use and for sale. Good results are obtained in growing sweet potatoes, melons, cantaloupes, tomatoes, cabbage, and beans.

The Sarpy very fine sandy loam is one of the earliest soils in the county. It is easy to cultivate, and only light implements and draft power are necessary. Very little manure is applied.

As in the case of the Sarpy silty clay loam, the price of this soil has a wide range. The determining factors are chiefly the frequency of overflow, location, and condition of the land.

SARPY LOAM.

The surface soil of the Sarpy loam consists of about 15 inches of grayish-brown to brownish-gray (when dry) friable loam. The subsoil is a grayish-brown heavy loam to light silty clay loam which

passes at about 30 inches into a grayish-brown or light grayish brown, lighter textured material, varying from a very fine sandy loam to a loamy sand or sand. The surface soil contains a relatively large percentage of very fine sand and is rather low in organic matter. In most places the soil, subsoil, and substratum are strongly calcareous.

In the lower lying areas of this type the surface soil may be dark grayish brown in color and quite silty in texture. This variation is usually accompanied by a very fine sandy loam or light loam in the lower subsoil. In higher lying areas there is considerable fine sand throughout the soil section, and the coarser textured substratum may lie closer to the surface. Spots occur in a few of the lower lying areas where there is little variation in texture throughout the entire soil section.

The Sarpy loam is developed along the Des Moines and Raccoon Rivers. It occurs in rather narrow discontinuous strips, varying in width from a few rods to three-eighths of a mile. The surface is flat to very gently undulating and lies from 4 to 10 feet above the normal level of the streams. Surface drainage is good. Internal drainage tends to be excessive in the small part of the type that occupies higher lands and in areas where the coarse substratum lies at shallow depths. On these areas crop yields are likely to be curtailed in excessively dry seasons. Over the greater part of the type, however, the soil is very retentive and crops rarely if ever suffer from lack of moisture. Unless diked, the soil is subject to overflow.

This is a rather important agricultural soil. Approximately 75 per cent of it is under cultivation; the rest is occupied by towns or is in pastures. A good growth of native grasses and some timber, consisting chiefly of oak, ash, elm, walnut, willow, and haw, are found in most of the pastures.

The most important crop on the Sarpy loam is corn. Wheat and oats are next in importance. The growing of truck crops, especially sweet corn, tomatoes, cabbage, and beets, for the Des Moines market is an important industry in the vicinity of Levey. These give good yields. Hog raising is the chief live-stock industry.

Where the soil is diked to protect it from overflow, corn ordinarily produces 40 to 50 bushels per acre, oats 35 to 45 bushels, and wheat 20 to 25 bushels. Clover and timothy yields from 1¼ to 1¾ tons of hay. Little alfalfa is produced on this soil. On the unprotected parts of the type the yields of the various crops in years of overflow depend upon the extent of injury done, and this depends to a great extent on the time at which the flood occurs. If the flood occurs so late in the season as to make impracticable the planting of corn for its grain yield, corn or sorghum is planted for forage purposes. On

the higher lying areas of shallow soil, previously described, wheat and oats give good returns, but corn may burn badly in dry seasons.

SARPY SILT LOAM.

The surface soil of the Sarpy silt loam is a grayish-brown silt loam. The subsoil, from about 15 to 30 inches, is a brownish-gray to grayish-brown heavy very fine sandy loam; below 30 inches it is a brownish-gray to gray very fine sand. The surface soil is moderately high in organic matter, and in uncultivated land may have a dark grayish brown color. The soil and subsoil are quite uniform in texture over their entire occurrence. Both are calcareous.

The Sarpy silt loam is most extensively developed along the Raccoon River and in the Des Moines River flood plain south from Johnston. It occupies a higher level than the most of the Sarpy silty clay loam, but is all subject to overflow. The surface is flat to gently undulating or sloping, and the drainage is fairly good.

Most of the Sarpy silt loam is under cultivation. The same field crops are grown and yields obtained in normal years as on the Sarpy loam. It is as easy to cultivate as the latter soil and can be worked under as wide a range of moisture conditions.

Ordinarily land of the Sarpy silt loam sells at $150 to $200 an acre. The price depends largely upon the location.

The Sarpy silt loam is farmed much the same as the Wabash loam. Little or no manure is applied, and very few farmers follow any system of crop rotation.

Where protected from overflows, land of this type ordinarily sells for $150 to $225 an acre. The price of the rest of the type ranges from less than $100 to $200 an acre, depending upon the frequency of overflow, the state of cultivation, and the location.

SARPY SILTY CLAY LOAM.

The typical Sarpy silty clay loam, to a depth of about 15 inches, is a grayish-brown to dark grayish brown silty clay loam. This is underlain by a dark brownish gray to brownish-gray silty clay loam, which grades at about 30 inches into a brownish-gray very fine sandy loam. The entire soil section is quite variable within certain limits. The surface soil is rather low in organic matter, but in the lower lying areas the content is higher than typical and the surface soil is dark grayish brown in color. Even in a single area the lower subsoil may vary from a very fine sand, practically free from clay, to a light silty clay loam. Small areas of silty clay or clay are included in some of the areas along old sloughs. The entire soil section is calcareous.

The Sarpy silty clay loam occurs in the first bottoms along the Des Moines and Raccoon Rivers. Most of it is low lying and subject to

frequent overflow, though it is encountered at elevations ranging from 2 to 10 feet above the river bed. The type may occur as narrow strips along the present stream channel, but usually it lies back from the stream along older channels and sloughs. The surface is flat to undulating. Drainage on the lower areas is poor, but is good over the rest of the type.

Probably 60 per cent of this type is under cultivation. It is devoted chiefly to the production of corn, oats, and wheat. Corn is the principal crop. Some sorghum is grown for sirup and for forage. Truck farming is practiced in the vicinity of Levey. Sweet corn is the most important truck crop. It produces well and is most extensively planted in seasons when the soil is late in drying out. Cattle are grazed extensively on the lower lying areas. The lowest and poorest drained parts of these areas may support a growth of weeds and trees, but most of the land supports a growth of grass as well as timber.

In normal years, or on areas protected from overflow, the yields of the various crops grown on the Sarpy silty clay loam are good.

The soil is handled in much the same way as the associated type, the Sarpy loam. It, however, requires heavier draft for tillage operations, and can not be worked under as wide a range of moisture conditions. With care it works into a friable and rather mellow seed bed and is not inclined to bake and crack.

The selling price of the Sarpy silty clay loam protected from overflow is about the same as that of the loam. In other areas the price is quite variable and depends chiefly upon the frequency of overflow.

MUCK AND PEAT.

The surface material of Muck and Peat consists of 6 to 20 inches of dark-brown to black partly decomposed organic matter, derived from the remains of water-loving plants and grasses, with a small admixture of silt, clay, or very fine sand washed from the adjoining slopes. This surface material is loose and porous when dry, but when wet is spongy. Its average depth is about 15 inches. Near the center of the areas the material may be in the final stages of decomposition, very finely divided and black in color, but the most of it is fibrous and only partially decayed. The substratum is composed of an impervious clay which is nearly black or dark drab in the upper part but becomes lighter in color with increase in depth. Some coarse material may be encountered in the clay stratum near the 3-foot depth. Both the soil and the subsoil material are highly calcareous.

Muck and Peat occur in small, shallow depressions, or old ponds, where it was formed by the gradual accumulation of plant remains.

These areas are scattered over the flatter divides in the northern part of the county and on the terrace level along Beaver Creek and north of Des Moines. They usually contain from 5 to 15 acres, but a few north of Crocker are larger, containing 30 or 40 acres. The total area of this soil is relatively small. The surface is flat and natural drainage very poor.

In recent years much of the Muck and Peat has been tile-drained and put under cultivation with the adjoining soils. Corn is usually the first crop grown, but for the first few years after reclamation it does not produce as satisfactorily as later. The high moisture-retaining power of the surface material makes it warm up late in the spring, and in wet seasons the plants continue growth late in the fall and the grain fails to harden and mature properly. Some farmers report good results from growing corn the first year, during dry seasons. Early frosts cause more damage to corn on the Muck and Peat than on the adjoining soils. Oats are difficult to harvest because of their tendency to lodge in wet seasons. In the areas that are well drained and have been farmed a number of years, crops give nearly as good yields as on the Webster silty clay loam. Extensive truck farming has been started on one of the larger reclaimed areas of Muck and Peat 2 miles west of Herrold. Indications point toward good results with such crops as potatoes, cabbage, tomatoes, and onions.

Drainage is the main factor in determining the agricultural value of Muck and Peat areas. Experiments by the Iowa Agricultural Experiment Station show that while the peaty material may be deficient in lime, potash, and phosphorus, there is sufficient in the subsoil for ordinary crop demands, and applications of commercial fertilizers are not profitable.[8]

RIVERWASH.

Riverwash occurs in numerous small areas in bends or on small islands of the Des Moines and Raccoon Rivers. Riverwash consists of a mixture of fine, medium, and coarse sand with some small gravel patches. This material is shifted about, or added to, during each general rise of the stream.

Because of the frequency of overflow and the uncertainty of crop yields this soil is not cultivated. Where not barren the land supports a growth of willow or cottonwood.

SUMMARY.

Polk County, Iowa, is situated in the south-central part of the State. It is nearly square and embraces 582 square miles, or 372,480 acres.

[8] See Bul. No. 157, Iowa Agr. Expt. Sta.

The surface of the county is an even plain, drift-covered in the northern three-fourths and mantled with a silty material over the remainder. It varies from rolling along the rivers to flat or gently undulating farther inland. The drainage is effected by the Des Moines and Skunk Rivers, and is rather slow on the divides in the northern three-fourths of the county. The average elevation is between 975 and 1,010 feet above sea level.

The first rural settlement in the county was made in 1844. The population has steadily increased, and in 1920 was 154,029. Des Moines, the capital of the State, is located in the south-central part of the area. Its population in 1920 was 126,468.

The county is exceptionally well supplied with railroads. Local markets take practically all the farm products offered for sale.

The mean annual temperature is 49.3° F. The mean annual rainfall is 32.5 inches; the precipitation is favorably distributed for the growth of crops. Total crop failures are unknown. There is an average growing season of 171 days.

The agriculture of Polk County consists mainly of a combination of grain and stock farming. Corn is the principal crop. Other important crops are oats, clover, timothy, wheat, and alfalfa. Considerable trucking and fruit growing is carried on in the vicinity of Des Moines. Hog raising and beef-cattle raising and fattening are the most important live-stock industries. Several carloads of hogs and beef cattle are brought in annually and fattened. Dairying is practiced quite extensively in conjunction with general farming, especially within easy hauling distance of Des Moines.

There were 2,948 farms in Polk County in 1919, with an average size of 110.9 acres. Nearly half of the farms are operated by tenants. Farm land rents by the year for $5 to $10 an acre. In share renting two-fifths or one-half the production is given the owner, with cash rent for the hay and pasture land. A plentiful supply of labor is to be had, but much of it is transient and inclined to be rather unsatisfactory. Farm laborers receive $30 to $40 a month, with board and washing.

Values of good farm land in Polk County range from $175 to $225 an acre.

The soils of Polk County may be divided into three general groups, according to the parent material and the methods of formation, viz, upland soils derived from glacial drift, upland soils derived from silty material, and alluvial soil derived from reworked drift and silty material. Besides Riverwash and Muck and Peat, there are 14 soil series, embracing 31 soil types, in Polk County.

The upland soils derived from glacial drift are classed in the Webster, Carrington, Shelby, and Lindley series. The Webster clay loam and Carrington loam are the most important soils of this

group. The Shelby soils differ from the others in having more sand and gravel in the subsoil. The Lindley soils differ from the others in having a lighter colored surface soil and a more compact subsoil. The Webster soils differ from the Carrington chiefly in having a darker colored surface soil and poorer natural drainage.

The Webster clay loam is the most important corn soil in the county and is a very desirable soil for general farming. It occupies the flatter portions of the divides in the northern three-fourths of the county. The Webster silty clay loam usually occurs as narrow strips within areas of the clay loam. When thoroughly drained it is nearly as desirable as the clay loam for corn growing.

The Carrington loam is the most extensive soil in the area. It occurs on the more undulating and gently rolling areas in the northern four-fifths of the county. It is nearly as important as the Webster clay loam for corn growing. Other important crops are oats, clover, timothy, and wheat. The proportion of this soil in wheat is greater than in the case of the Webster soils. The shallow phase of the Carrington loam lies on stream slopes in the typical soil, and is devoted mostly to grazing. The Carrington fine sandy loam occurs principally on the gradual slopes to the north of the Des Moines and Skunk Rivers and north of Indian, Big, and Little Beaver Creeks. It produces nearly as well as the loam in normal years, but the yield may be slightly curtailed in dry seasons.

The Shelby loam occurs on a variable topography. It has a rather loose subsoil. Most of it is utilized for grazing. Crops yield well in favorable seasons, but suffer considerably in dry seasons.

The Lindley fine sandy loam practically all lies along the Des Moines River. It has a rolling topography and the most of it is used for grazing.

The upland soils derived from the silty material are included in the Tama and Clinton series. They differ chiefly in that the Tama soils are darker colored in the surface and do not have as compact subsoils.

The Tama silt loam occurs as the main upland soil in the southern one-fifth of the county. It produces good yields of all the crops commonly grown in this region. More wheat is grown in proportion to the other crops than on the glacial soils. It is one of the two important soils in the county for commercial fruit growing. The shallow phase of the Tama silt loam occurs chiefly in sloping areas of the typical soil south of the Des Moines River. It is devoted to the same crops and farmed in the same way as the typical soil. The Tama loamy fine sand is a minor type. It occurs in the Tama silt loam in the western part of Bloomfield Township and most of it is used for pasture.

The Clinton silt loam occurs in the southern tier of townships along the Des Moines and Raccoon Rivers. It has a rolling topography. A greater proportion of it is devoted to small grains than in case of the other upland soils. It supports several small commercial apple orchards.

The alluvial soils may be subdivided into high-terrace soils and first-bottom soils. The high-terrace soils are included in the Bremer, O'Neill, Waukesha, Buckner, and Chariton series. The Bremer soils differ from the Wabash soils of the first bottoms in occupying a higher position. The O'Neill soils differ from the other high-terrace soils in having a coarse substratum within the 3-foot section.

The Bremer silty clay loam occurs on the lowest of the second bottoms. It is one of the most valuable alluvial soils in the county for general farm crops. The yields of crops ordinarily obtained equal those on the Carrington loam. The Bremer clay, silt loam, and loam produce yields similar to those obtained on the silty clay loam.

The Chariton silt loam occurs within areas of the Bremer and Waukesha soils, and it is handled much the same as those soils.

The Buckner fine sandy loam is devoted to all the field crops common to this region, of which it gives good yields. It is also valuable for the production of truck crops.

The O'Neill fine sandy loam is developed on the highest terraces. It is highly prized as a trucking soil. It is inclined to be more droughty than the other important soils of the county, but gives good yields in normal years. The O'Neill fine sand occurs on small minor elevations and is used chiefly as pasture land. The O'Neill loam is not a very important soil in this county. Its productive power compares favorably with that of the Waukesha loam in favorable years, but not in exceedingly dry years.

The Waukesha loam is similar to the Carrington loam in all respects except in its origin and topographic position. It is the most extensive high-terrace soil in the county. The Waukesha silt loam occurs chiefly in the silt-covered region of the county. It is similar to the loam in productiveness.

The first-bottom soils include the Lamoure, Wabash, and Sarpy series. The Lamoure soils differ from the Wabash soils mainly in having a higher lime content and poorer natural drainage. The Sarpy soils differ from the others in having a lighter color and a lower subsoil lighter than the surface soil in texture.

The Lamoure silty clay loam, where well drained, produces excellent corn yields. Much of it is used for pasture and hay land.

The Wabash clay is the most extensive alluvial soil in the county, most of it occurring in one continuous area along the Skunk River. It forms some of the largest pastures in the county. It is a very productive soil. The Wabash loam, silt loam, and silty clay loam

occur chiefly as narrow strips along the creeks or along the Skunk and North Rivers. Where well drained, they give excellent yields when crops are not damaged by overflow. They are, however, devoted largely to grazing. The Wabash fine sandy loam is developed most extensively in the Skunk River bottoms. It produces well.

The Sarpy loam, silty clay loam, and silt loam are developed in the bottoms of the Des Moines and Raccoon Rivers. These soils are devoted to general farming and in the vicinity of Des Moines to trucking. They produce good average yields where protected from overflow. The Sarpy very fine sandy loam, where favorably located, is highly prized for the production of truck crops. Much of it is used for pasture land. It gives good returns of farm crops in normal years. The Sarpy fine sandy loam where cultivated is devoted mainly to the growing of corn and sorghum.

Areas mapped as Muck and Peat represent accumulations of vegetable matter occurring chiefly in shallow depressions or old ponds. With drainage and careful treatment for a few years after reclamation these soils may be made highly productive.

Riverwash includes low-lying, recent deposits of coarse material along the Des Moines and Raccoon Rivers. It is not cultivated and where not barren supports a growth of cottonwood and willow.

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[PUBLIC RESOLUTION—No. 9.]

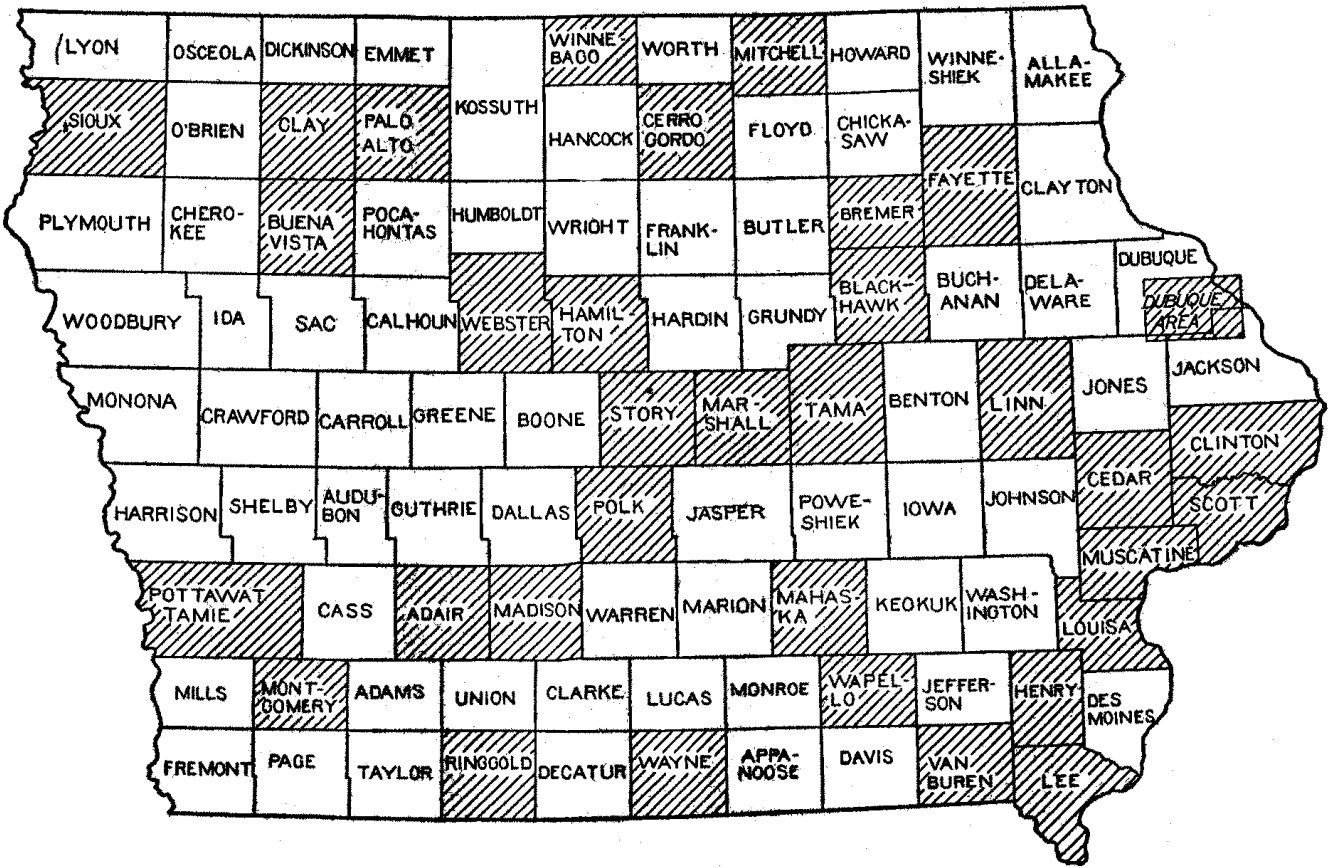
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]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