

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In Cooperation with the Iowa Agricultural Experiment Station

SOIL SURVEY
OF
CARROLL COUNTY, IOWA

BY

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U. S. Department of Agriculture

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COUNTY SURVEYED

Carroll County is in the west-central part of Iowa, in the third tier of counties east of Missouri River. It is about 24 miles square and contains 573 square miles or 366,720 acres.

Geologically, Carroll County lies about equally within the limits of the Missouri loess and Wisconsin drift areas of the State, the line separating them running through Breda, Carroll, and Coon Rapids. West of this line is a dissected plain where the crests of the divides average about 50 feet higher than the valley floors. The divides, however, are well rounded, and the slopes to the streams are smooth. The general landscape appears more level than it actually is. East of this line, or throughout the glaciated region, the relief is undulating or rolling. Except in the northeast corner where rough, rugged strips of country occur adjacent to the bottoms of Raccoon River the surface ranges from gently undulating to nearly level.

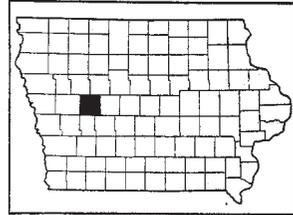


FIGURE 1.—Sketch map showing location of Carroll County, Iowa

First bottoms are developed along all the rivers and creeks of the county. Many of these strips are broad. The broadest lie along the Middle Raccoon River from a point south of Lidderdale to the vicinity of Carrollton. With the exception of a few comparatively small isolated areas along Middle Raccoon River and some of the larger creeks, terraces occur only in the valleys of Raccoon River in the northeastern corner of the county.

Carroll County ranges in elevation from 1,570 feet above sea level in the west-central part to 1,100 feet in the northeast part. The elevations¹ at Breda, Arcadia, and Manning, in the western part, are respectively 1,365, 1,425, and 1,339 feet; at Carroll and Templeton, near the central part, 1,266 and 1,452 feet, respectively; at Lanesboro, in the extreme northeast corner, 1,148 feet; and at Coon Rapids, near the extreme southeast corner, 1,174 feet. The greater part of the county has a prevailing slope toward the east, but a small area in the southwest part drains southwestward.

Carroll County was created by special act of the legislature July 16, 1855. According to the 1920 census report the population is 21,549. The rural population of 17,295 is well distributed. The inhabitants are almost wholly American born. In the western half of the county people of German descent predominate, and in other parts people of English, German, and Irish descent are about equally distributed.

Carroll, the county seat and principal town, is located near the geographical center of the county and has a population of 4,254.

¹ GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES (FOURTH EDITION.) U. S. Geol. Survey Bul. 274, 1,072 pp. 1906.

Manning, in the extreme southwest corner, has a population of 1,863 and is the next largest town, and Coon Rapids, in the extreme southeast part, ranks next with 1,328 inhabitants. Glidden, with 867 inhabitants, Breda with 419, Arcadia with 375, Templeton with 373, Dedham with 360, Ralston with 200, Lidderdale with 163, Halbur with 186, and Maple River with 108 are other important railroad towns.

Farming and livestock raising are the principal industries, and only comparatively few manufacturing plants are located within the county. Carroll has a wagon-tongue ends factory, flour mill, and creamery. Manning also has a flour mill and creamery. A creamery and concrete-block factory are located within the limits of Coon Rapids. Creameries are located at Breda, Templeton, Halbur, and Roselle.

The transportation facilities of Carroll County are excellent. The main line of the Chicago & North Western Railway, a double-track line which crosses the county in an east-west direction passing through the towns of Ralston, Glidden, Carroll, Maple River, and Arcadia, affords a direct outlet to eastern and western markets. A branch line of this same system leaves the main line at Maple River and runs north through Breda, serving the northwest part, and another branch, which traverses the southwest part, connects Carroll, Halbur, and Manning with southwestern points. A third branch of this same system leaves the main lines at Manning and gives an outlet to the south. A small shop and roundhouse at Carroll is maintained by the Chicago & North Western Railway. The Fort Dodge-Council Bluffs division of the Chicago Great Western Railroad parallels the Chicago & North Western from Manning to Carroll and continues in a general northeasterly direction, passing through the towns of Lidderdale and Lanesboro. The southern part of the county is served by the main line of the Chicago, Milwaukee & St. Paul Railway, which is double tracked throughout the county.

The road system of Carroll County is very complete. Most of the roads have been brought to grade and are kept in good condition. In the glaciated region practically 70 per cent of the roads have been graveled, but throughout the loess hills only the county roads are being surfaced. During the year of the survey (1926) considerable work was in progress, and the program will be continued. A large quantity of excellent road-building material is found in Carroll County. The Lincoln Highway crosses the county in an east-and-west direction, following closely the main line of the Chicago & North Western Railway. A north and south highway, Federal road No. 71, passes through Carroll.

Practically every farm is reached by telephone and rural mail service. Power lines radiate from Carroll and Manning and deliver electric current to a number of farms. Unit power plants are also in use in some places. Consolidated schools have been erected in most of the towns, and many small township schools are in operation.

The principal outside markets are Chicago, Omaha, Kansas City, and Sioux City.

CLIMATE

The climate of Carroll County is favorable for the production of all staple crops common to this section of the country. The winters are long and many of them are severe. The average temperature

for the three winter months is 21° F. An absolute minimum of -40° has been recorded during January. However, crops seldom winterkill.

The summers are comparatively short and hot. Wide fluctuations in temperature are common, and occasionally extremely hot spells occur. When strong, hot winds from the southwest accompany these hot spells crops that have not been properly cultivated are inclined to fire. The mean recorded temperature for the three summer months is 70.9° F. and the maximum temperature recorded is 105° in July.

The average date of the last killing frost is May 3 and that of the first is October 4. This gives an average frost-free season of 154 days, which is sufficient to mature all crops, except during abnormal seasons when early rains delay planting. Such damage is always of local extent and usually occurs in the lower, more poorly drained areas. The date of the latest killing frost recorded is May 25, and that of the earliest is September 12.

The precipitation is well distributed for the growing and harvesting of crops. The heaviest rainfall occurs during the growing season, in May, June, July, and August. The total precipitation for the driest year (1894) recorded at Carroll was 20.42 inches and that for the wettest year (1909) was 44.92 inches. The mean annual precipitation is 31.60 inches.

Table 1, compiled from data recorded by the Weather Bureau station at Carroll, which is near the center of the county, shows the more important climatic conditions in Carroll County.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Carroll

[Elevation, 1,265 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1894)	Total amount for the wettest year (1909)
	° F.	° F.	° F.	Inches	Inches	Inches
December.....	23.8	62	-26	0.98	0.96	1.45
January.....	17.4	59	-40	.78	1.17	1.77
February.....	21.9	62	-29	1.06	1.00	.52
Winter.....	21.0	62	-40	2.82	3.13	3.74
March.....	36.0	85	-15	1.69	1.76	1.50
April.....	48.5	94	18	2.95	2.80	2.53
May.....	59.9	94	21	4.56	1.10	6.28
Spring.....	48.1	94	-15	9.20	5.66	10.31
June.....	68.4	99	39	4.78	1.51	9.79
July.....	73.2	105	42	3.58	1.73	4.51
August.....	71.1	103	37	3.85	1.61	.80
Summer.....	70.9	105	37	12.21	4.85	14.60
September.....	63.7	98	26	3.47	3.29	5.23
October.....	51.6	89	11	2.53	3.20	3.78
November.....	36.1	77	-2	1.32	.29	7.26
Fall.....	50.5	98	-2	7.37	6.78	16.27
Year.....	47.6	105	-40	31.60	20.42	44.92

AGRICULTURE

Agriculture has been the leading industry in Carroll County since the first settlements by white men were made. In the early days little effort was made to raise more farm products than were needed for home consumption, as no markets for any surplus were accessible. For this same reason, the early settlers devoted much time to hunting and trapping in order that cash might be obtained to buy those commodities that could not be raised on the small farms. Wheat constituted the principal crop, but considerable flax was grown on the more poorly drained soils. The agricultural growth was slow at first, but with the advent of the railroads the influx of settlers increased rapidly.

Table 2 shows at a glance the acreage and production of the principal crops for the last six censuses.

TABLE 2.—Acreage and yield of the principal crops in stated years

Crop	1879		1889		1899	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	67,328	2,671,169	114,179	4,560,035	121,577	4,838,880
Oats.....	9,736	302,473	44,687	1,741,626	60,213	2,268,860
Wheat.....	47,230	680,086	5,684	67,074	29,032	458,190
Barley.....	4,814	110,137	13,620	391,786	4,202	118,200
Rye.....	398	7,314	429	6,074	295	2,990
		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
Hay (all kinds).....	11,223	18,744	40,476	59,575	686	1,344
Coarse forage.....						
Crop	1909		1919		1924	
	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>	<i>Acres</i>	<i>Bushels</i>
Corn.....	112,453	3,952,859	117,025	5,237,779	116,732	3,387,157
Oats.....	61,484	1,458,241	73,313	2,603,964	74,548	2,756,744
Wheat.....	6,951	78,291	13,024	140,335	1,827	39,592
Barley.....	6,939	117,450	1,347	32,218	2,254	60,435
Rye.....	11	190	149	1,989	16	320
		<i>Tons</i>		<i>Tons</i>		<i>Tons</i>
Hay (all kinds).....	1,145	2,019	2,410	3,871		53,988
Coarse forage.....	478	1,104	2,236	5,185		

The average value of all farm property to the farm in Carroll County increased from \$3,217 in 1880 to \$54,901 in 1920. During this same period the percentage of farms operated by owners decreased from 73.9 per cent to 49.9 per cent, whereas the percentage of those operated by tenants increased from 26.1 per cent to 49.1 per cent.

The value of agricultural products has shown a steady growth for each decade. The 1920 census report gives the value of all cereals as \$9,355,551, of all domestic animals as \$6,151,440, of dairy products as \$404,454, and of poultry and eggs as \$679,157.

At present the agriculture of Carroll County consists of the growing of grain and hay, the raising and feeding of hogs, beef cattle, and sheep, and, to a small extent, of dairying.

Corn is the principal crop and occupies the largest acreage. According to the Iowa Yearbook for 1925, there were in that year 135,849 acres devoted to corn which produced 6,072,450 bushels or

an average of 44.7 bushels to the acre. Highly improved sections of the county produce much larger yields, ranging from 60 to 90 bushels to the acre, and the poorer farms that are operated by tenants show a much smaller yield. Average yields in the western half of the county are slightly larger than those in the eastern half. The lowest yields are reported from the extreme northeast corner. Reid Yellow Dent and strains of this variety are the most popular and occupy approximately 60 per cent of the total corn acreage. Throughout the western half of the county very little white corn is grown, but in the northeast quarter there seems to be a preference for Iowa Silvermine and Silver King. A small acreage is also devoted to Iowa Goldmine. The seed corn is usually selected in the field at husking time. Some farmers test it for germination, especially when early frosts have damaged the crop. The greater part of the corn crop is husked in the field, from 10 to 15 per cent is hogged down, and a constantly increasing acreage is cut for silage. Where grown for silage, soybeans are planted with the corn by means of a special attachment to the corn planter. The 1925 Iowa Yearbook reports that 2,527 acres of corn were cut for fodder, 8,374 acres were hogged down, 5,539,953 bushels were husked for grain, and 10,695 tons were cut for silage. Approximately 80 per cent of the corn is used for feed within the county. It is either fed on the farms where it is raised or is sold in parts of the county where the feeding of cattle is extensively practiced. Most of the corn crop sold to outside markets comes from the eastern half of the county and is sold through cooperative elevators.

Oats rank second in importance. They fit well in the general rotation. During 1924 the 74,548 acres planted produced 2,756,744 bushels. The favorite varieties, in the order of their importance, are Albion, (Iowa 103), Green Russian, Silvermine, Kherson, and Richland, (Iowa 105). The average yield, over a period of years, is 40 bushels to the acre, though yields of 50 and 60 bushels are not uncommon during favorable seasons. Oats are generally broadcast by means of an end-gate seeder. The greater part of the crop is used on the farms as feed for the work animals, cattle, and hogs, and only about 15 or 20 per cent is shipped to outside markets.

Hay and forage crops rank third in importance. According to the 1925 census report there were 37,141 acres in tame hay in 1924 and 3,999 acres in wild grasses. In addition 3,077 acres of corn and a small percentage of the small grains were cut for roughage. Timothy and clover, grown separately and together, comprise most of the hay crop. During 1924, 23,056 acres were in clover and timothy, 4,364 in clover alone, and 3,080 acres in timothy alone. At present timothy is not grown extensively, and the tendency is to plant more clover alone. Yields of hay range from 1½ to 2 tons to the acre. All the hay is used on the farms for feed, and the supply is not equal to the demand. Throughout those sections of the county where cattle feeding is a leading industry, a large tonnage is shipped in each year.

Clover is an important hay and forage crop, and during the year of the survey (1926) a special count of the clover acreage showed that 17,710 acres were devoted to this crop alone. This is a decided increase over the acreage reported in the 1925 Iowa Yearbook, and

the consensus of opinion seems to be that this acreage will continue to increase. Except in Newton Township, the largest acreage devoted to clover is in the western half of the county. Medium red seems to be the most popular variety. Approximately 40 per cent of the clover acreage is sown with oats, which serve as a nurse crop. When the crop is cut for hay, yields of 2 or 2½ tons to the acre are common.

Alfalfa is becoming a popular hay crop, and a constantly increasing acreage is being grown. The 1926 Iowa Yearbook reports a total acreage of 1,995, and a special count during the year of the survey shows a total of 1,990 acres, the greater part of which is in the glaciated or eastern half of the county. During 1925, 20 carloads of alfalfa hay were shipped in to augment the local supply. The varieties best liked are Grimm and Dakota No. 12. Grimm is the hardier of the two and is less susceptible to damage by severe freezes. The crop is seeded either in the spring or fall, both practices giving equally good results. When planted in the spring small grain is used as a nurse crop. The rate of seeding is usually 15 pounds to the acre. Three cuttings are commonly obtained, and yields range from 2½ to 3½ tons to the acre. Liming and inoculation insure good stands, but after the roots have penetrated deep enough the supply of calcium seems to be sufficient for crop needs. Alfalfa usually remains on the same land from 3 to 10 years. It is eventually crowded out by bluegrass, but scarifying the fields once a year eliminates this menace to a considerable extent.

Sweetclover is a comparatively new crop but is fast growing in favor. Both the yellow and white varieties are grown. It is either planted with small grain in the spring or alone in the fall, the rate of seeding ranging from 8 to 12 pounds to the acre. A small acreage threshed for seed produces an average of 10 bushels to the acre.

Soybeans are grown to some extent, and the favored varieties are Ito San and Manchu. Only one field was noticed where the crop was grown alone, the usual practice being to plant soybeans with the corn that is to be hogged down or cut for silage.

According to the 1925 agricultural census the 2,254 acres planted to barley in 1924 produced 60,435 bushels, or an average of 27 bushels to the acre. The seed is broadcast at the rate of about 2 bushels to the acre. This crop fits in the rotation in much the same way as oats and is used entirely as hog feed on the farms of the county.

At present the wheat acreage is small. Formerly wheat was an important cash crop and ranked second to corn in acreage. According to the 1925 census report there were only 1,827 acres planted to wheat during 1924. The production was 39,592 bushels. Turkey and Iobred are the most popular varieties. The greater part of the winter crop is drilled in about the last of September, as after this date there is less danger of damage by the Hessian fly. Most of the crop is sold or exchanged at the flour mills in Carroll, Manning, and Westside, Crawford County. A small tonnage, produced in the vicinity of Glidden, finds its way to outside markets through the cooperative elevator located in that town.

Rape is rather extensively grown for hog pasture. It is usually sown with corn or oats. A little rye is grown for pasturage. Buck-

wheat is planted now and then as a catch crop, and flax is sometimes grown on poorly drained land. Sorghum, both for forage and sirup, is produced to a slight extent. Some millet and Sudan grass are grown for forage and pasturage.

Gardens are maintained on most farms, and all varieties of vegetables adapted to this part of the country are produced for home consumption. Throughout the sandier sections in the northeastern part of the county a few truck farmers grow watermelons, cantaloupes, and vegetables on a commercial scale. Little care is given the trees in the small orchards, and the fruit is faulty. Grapes, raspberries, and strawberries are produced on most farms of the county.

The principal livestock industry is the raising and feeding of hogs. The Duroc-Jersey, Poland China, and Chester White are the most popular breeds, and a few head of Hampshire and Tamworth hogs are raised. About 10 or 12 grade brood sows are kept by most farmers. Purebred sires are used. About 60 head of hogs is the average number to a farm. The hogs are either sold directly to buyers or are shipped through cooperative associations. During bumper crop years, when feed is plentiful, feeders are often brought in from Sioux City and Omaha. Most of the fattened hogs are shipped to Chicago and Omaha.

The raising and feeding of beef cattle is also important. A few of the herds are purebred, but most of them consist of grade animals. Shorthorn and Hereford cattle predominate, but there are some Aberdeen Angus. Feeders are bought on the Omaha or Sioux City exchange and shipped into the county late in the fall. They are first turned into the stubble fields or put on pasture, then are fed intensively for a period ranging from 100 to 160 days. Corn is used during the husking season, and later an added ration of hay and silage is fed. Chicago is the principal market for the finished cattle.

Dairying is carried on mainly as a side line, except in the vicinity of Carroll and Manning, where several farmers devote their time exclusively to this industry. From 7 to 12 cows are commonly kept. The Holstein seems to be the most popular breed, though a number of Guernsey herds were seen. The milk is separated on the farms and the cream sold to creameries located at Carroll, Breda, Templeton, Manning, Halbur, and Roselle or to the cream stations in the smaller towns. The cream sold in the smaller towns is shipped to outside markets. The butter manufactured in the local creameries is sold both in the towns of the county and in distant markets.

The production of chickens and eggs is very remunerative, and according to the United States census of 1920 these products were valued at \$679,157 in 1919. The poultry consists of chickens, ducks, geese, turkeys, and a few guinea fowls. The chickens and eggs are either sold to the produce houses located in the principal towns of the county or are exchanged for necessities at the stores.

A few farmers keep sheep, mainly Shropshire and Oxford grades. Some of the small flocks are kept as a side line. A few farmers ship in feeders from the West, and the sheep are turned into the stubble fields for a short time, then are fed intensively from 40 to 60 days or until fit for market. The local flocks are sheared each year, and the wool is marketed through wool-growers' associations.

The adaptation of certain crops to certain soils is recognized in only a general way. The better-drained bottom-land soils are considered richer and capable of producing larger yields of corn than other soils. The more poorly drained Wabash and Lamoure soils are considered more valuable for pasture and are usually left in their native condition. Melons and all kinds of garden truck produce best on the sandier-textured soils of the northeastern part of the county.

Barnyard manure is carefully saved on most farms and scattered over the stubble fields and grassland before plowing, but the supply is insufficient. As most of the soils are acid, especially in the surface layer, the use of ground limestone has proved of great value. Its use is increasing, and during the year of the survey (1926) a number of carloads were shipped in. At present, lime is applied only to the alfalfa and clover land, but its use could be profitably extended to all soils devoted to the production of the staple crops. Commercial fertilizers are seldom used except experimentally.

Corn is the principal crop, and all farming operations are centered around its production. Wherever possible, the land for corn is fall plowed, and at present the fall-plowed land represents approximately 50 per cent of the total acreage in corn. The following spring the land that has been broken in the fall is disked and harrowed. Where corn succeeds itself the land is put in condition by disking and harrowing just before planting. For the last few years about 30 per cent of the cornland has been "cultipacked" just ahead of the planter, a practice that has proved of great value. The depth of plowing is usually from 5 to 7 inches, and the seed bed is well prepared. Corn is planted between May 5 and May 20. It receives three or four cultivations and is generally laid by July 4.

Oats customarily follow corn. The oat crop is planted about April 1 and harvested about July 1. Clover or clover and timothy is sown with about 40 per cent of the oats, and after the oats are harvested is left for one or two years. The first year the clover and timothy is usually pastured lightly and in the second year the first crop is cut for hay, the second is pastured, and the residue is turned under as green manure. A few farmers leave the timothy for a third year for hay, but this practice is declining. Sweetclover, alfalfa, and soybeans, especially the first two, are being grown more extensively. Alfalfa is seldom turned under until it has remained on the land from three to five years. Sweetclover is pastured for two years.

Crop rotations are practiced only in a rather broad, general way, except by the more progressive farmers. Corn is grown from two to four years, oats one year, and after this corn is either grown for one year, followed by clover, or clover and timothy are planted. The most popular rotation consists of corn, corn, oats, and clover.

The farm buildings are, as a rule, substantial and well kept. Most of the farmsteads throughout the loess country are more pretentious than those in other parts of the county. Many farmhouses are equipped with modern conveniences such as running water, electricity, and heating plants. The farms are all fenced in, either with a combination of woven-wire and barbed-wire fencing or with barbed wire alone.

According to the 1925 census, there are in Carroll County 345,776 acres in farms, 250,440 acres of which are in crops and 76,677 acres in pasture land. The average size of farms is 163.6 acres, although much larger holdings are found in some places, many of them a half section in size. The total number of farms is 2,113. Of these, 851 are operated by full owners and 1,065 by tenants.

According to the 1925 Iowa census 135,739 acres of land were leased in 1924. This is 38 per cent of all land in farms. An average price of \$7.13 an acre was paid. Land is rented both for cash and on shares, but chiefly for cash. The share rent is usually half the corn and two-fifths of the small grains. Day laborers receive an average of \$2.50 with board, and regular farm laborers receive \$60 a month with board, or, if married, a home, garden, cow, and other perquisites. During corn harvest huskers receive 6 or 7 cents a bushel, in addition to board.

During 1926 the price of land, based on the few transfers that were made, ranged from \$145 an acre in the northeast part of the county to \$225 throughout the western half. The price depends largely on the character of the land, location with respect to railroads and towns, improvements, and drainage.

SOILS

Carroll County lies in the prairie region of the United States where a temperate climate, a smooth surface, and an adequate supply of soil moisture have favored a luxuriant growth of grasses. The most important characteristics of the soils have been produced by these regional influences. The most striking characteristic and one common to soils developed under prairie conditions is the large amount of organic matter in the surface layers. This organic matter, accumulated in the soil through the penetration and decay of grass roots, imparts to the soils their characteristic dark color. The color of the surface soils, which ranges from dark grayish brown to black, and the depth to which the dark color has penetrated are determined largely by the supply of soil moisture during soil formation.

The soils of Carroll County may be divided into two principal groups on the basis of the characteristics produced by the drainage conditions under which they have developed. In the soils of the first group, which occur on the smooth but undulating or rolling upland, surface and subsoil drainage are good. Under these optimum moisture conditions, the forces of weathering, including leaching and oxidation, have proceeded without interruption, and the profile developed in these soils may be regarded as the mature and normally developed profile of the region. In these soils, from the surface downward, there are three broad divisions or layers. In soil literature, these layers are usually given the conventional designations of A, B, and C horizons. These horizons are everywhere present in the normally developed soils, but important subdivisions of them may occur in some soils but not in others. The important and universal characteristics of these horizons are as follows: (1) The surface layer, which varies from 8 to 20 inches in thickness, has a finely granular or single-grained structure, a high content of organic matter, and a very dark grayish-brown color; (2) the yellowish-brown or brown subsoil layer, which continues to a depth ranging from 30

to 50 inches, varies only slightly in color in all the well-drained soils of the county but is slightly or considerably heavier in texture than the surface layer; and (3) the parent material from which the soils are derived, little modified by the soil-forming processes. The texture may be either lighter or heavier than that of the subsoil layer, and the color varies with the character of the parent material, which in the upland soils in this county is either loess or glacial drift, both of which are silty.

Variations in this general profile are caused by topographic features which control moisture and erosion and by the influence, particularly in the substratum, of the parent material. The soils of the Carrington, Tama, and Waukesha series are typical of the well-drained group. The Clarion soils are similar to these in appearance and have most of the essential characteristics of the group, but leaching has not proceeded so far as with the other soils and residual or parent material lime remains within 3 feet of the surface. The O'Neill soils have gravelly or sandy subsoils and are well leached. The Pierce soils, which occur on eroded knolls and ridges, have gravelly subsoils, but in these soils also lime lies within 3 feet of the surface.

The second major group comprises soils that have existed under conditions of more or less excessive moisture and have, therefore, not developed the normal profile of the region. The broad swales and immature drainage ways throughout the glaciated uplands and the flat terraces cover a large area. The natural drainage of these areas was inefficient, so that water accumulated after rains and remained on the surface until it was removed by slow seepage or evaporation. On the flood plains and low terraces of the streams, which have a high water table and are frequently flooded, the soils have developed under a cover of water for a part or all of the year.

The Webster soils have developed on the poorly drained uplands. Leaching has not removed the lime of the parent material below the 3-foot depth. The Bremer and Fargo soils have developed on terraces where a flat surface and rather impervious subsoils have restricted drainage. The Bremer soils are low in lime content, but the Fargo soils contain lime within 3 feet of the surface. The Wabash and Lamoure soils occupy the flood plains and low terraces along streams. The Wabash soils are well leached, but the Lamoure are highly calcareous.

The principal characteristics by which the two major groups have been differentiated have been imparted to the soils by the soil-forming processes, and no account has been taken of the processes of the accumulation of the mineral matter from which the soils have been developed. In subsequent pages, the grouping of the soils into series has included a consideration of the source of the soil material.

The parent materials of the upland soils are the Missouri loess and the drift left over the region by the Late Wisconsin glaciation. The loess, which occupies the southwestern part of the county, occurs as a mantle over the drift. Over the greater part of this region it ranges from 3 to 40 feet in thickness. It consists mainly of fine-grained siliceous silt with a smaller percentage of clay and various grades of sand. When the material was deposited, supposedly by wind action, it was probably calcareous but, if so, the free down-

ward movement of the drainage waters has removed the carbonates to a depth of many feet except in a few small areas. The most important modification of this material by the soil-forming processes has been the incorporation of organic matter in the surface layers. The heavier, or subsoil layer, of the loessial soils in this area is but weakly developed, so that it is only slightly heavier in texture than the surface soil. Soils of this origin in Carroll County have been classed in the Tama series.

The glacial drift is the surface covering of the northeastern half of the county and for the narrow, deeply cut valleys in the southwestern part where erosion has removed the loess. The well-oxidized upper part of the drift consists of a yellowish-brown, gritty, or fine sandy clay loam or fine sandy clay. At greater depths, the material is either yellowish-brown, gritty fine sandy loam, splotched or streaked with rust-brown and black iron stains, or pale-yellow, light-textured loam, streaked and spotted with gray and black. Boulders and gravel may occur on the surface or at any depth in the soil, but, as a rule, they become more abundant below the 3-foot depth. The glacial drift has not leached so rapidly as the loess, and in all areas lime remains within 6 feet of the surface. Where the lime has been leached below the 3-foot depth, the soils have been classed in the Carrington series, but where lime is within 3 feet of the surface, the soils, although similar in appearance to soils of the Carrington series, have been correlated in the Clarion series. Unleached calcareous drift soils with gravelly subsoils are classed in the Pierce series.

The parent materials of the alluvial soils have been washed down from both loess and drift areas, and no attempt has been made to separate the alluvial soils on the basis of the derivation of their parent materials. The soils of the high terraces have been acted on for so long a time by the soil-forming processes that they have developed profiles similar to those of the well-drained soils of the uplands. The poorly drained alluvial soils, however, have immature profiles.

The various soils in the county are grouped in series on the basis of their color, origin, surface relief, composition, and structural characteristics. The series are subdivided into soil types on the basis of the texture of the surface soils.

The soils of the Carrington series are characterized by very dark grayish-brown surface soils and yellowish-brown or light-brown subsoils. Leaching has extended to a depth of several feet, and both surface soil and subsoil are noncalcareous. Below the weathered part of the soils is glacial drift, which continues to a depth of many feet. The relief varies from undulating to rolling, and both surface and subsoil drainage are sufficient for crop needs. Soils of this series are extensively mapped throughout the glaciated section of the county. The Carrington series is represented in Carroll County by Carrington loam and Carrington fine sandy loam.

The surface soils of members of the Tama series are very dark grayish brown, and the subsoils are yellowish brown. Carbonates occur in places within a depth of 3 feet, but in many extensive areas leaching has removed the layer of lime concentration to a much greater depth. The Tama soils are derived from weathering of the Missouri loess. The relief varies from undulating to rolling, the

ridges, as a rule, having well-rounded crests and even slopes. Drainage is good, and the subsoils are retentive of moisture. Tama silt loam is the only member of this series mapped.

Soils of the Webster series have very dark grayish-brown or black surface soils, and gray or mottled gray and brown subsoils. The subsoils are heavy in texture, ranging from silty clay loam to clay, and are commonly calcareous, effervescing where tested with acid. Soils of this series are derived from the underlying glacial till through processes of weathering, leaching, and oxidation. The surface is undulating or level, and drainage in most places is poor. The Webster series is represented in Carroll County by the loam and the silty clay loam members.

The surface layers of the Clarion soils, to a depth ranging from 12 to 16 inches, are very dark grayish brown or almost black when wet. The subsoils are predominantly yellowish brown in the upper part and grayish yellow in the lower. In most places they effervesce with acid below a depth of 2 feet and everywhere within a depth of 3 feet. These soils are of glacial origin and differ from the Carrington soils in the presence of a grayish-yellow calcareous layer. The surface varies from undulating to strongly rolling, and drainage is well established in most places. Clarion loam, Clarion fine sandy loam, and Clarion fine sandy loam, steep phase, are the members of the Clarion series mapped.

The surface soils of members of the Pierce series are dark grayish brown or very dark grayish brown and are underlain at a slight depth by lighter-textured sandy or gravelly subsoils. As a rule the upper subsoil layers are sandy or gravelly loam and grade between depths of 1½ and 2 feet into beds of sand and gravel. The lower part of the subsoils effervesces with acid in most places. Soils of this series occur only on gravelly knolls, ridges, and outwash plains. The relief varies from level to hilly. Drainage is excessive and the soils are droughty. Pierce sandy loam is the only member of the Pierce series mapped.

The Waukesha soils have very dark grayish-brown surface soils and yellowish-brown or light-brown subsoils. The subsoils are commonly heavier in texture than the surface soils but are not compact, tough, or impervious. These soils are not calcareous within several feet of the surface. They occur on the better-drained benches above the reach of ordinary overflow. The surface is level or gently sloping. Drainage is good and the subsoils are retentive of moisture. Waukesha silt loam is mapped.

The surface soils of members of the Bremer series are predominantly very dark grayish brown or almost black. They are underlain by dark-gray, yellowish-brown, or dark grayish-brown heavier-textured subsoils. Neither surface soil nor subsoil is calcareous. These soils occur only on terraces where drainage is restricted. The surface is flat or gently sloping toward the streams. Bremer silt loam and Bremer silty clay loam are mapped.

Soils of the Fargo series have very dark grayish-brown or black surface soils underlain at variable depths by heavier-textured subsoils. The subsoils are dark drab or mottled gray, brown, and yel-

low. The soils of this series differ from the Bremer soils in that both the surface soil and subsoil contain a large amount of lime, usually sufficient to cause effervescence. Soils of this series occur only on the more poorly drained terraces. The surface is level. The silt loam and silty clay loam members of the Fargo series are mapped.

The surface soils of members of the O'Neill series are very dark grayish brown when dry and almost black when wet. The subsoils are light brown or yellowish brown and grade, at a depth varying from 18 to 24 inches, into beds of stratified sand and gravel. The surface is level and, owing to the presence of underlying beds of gravel, drainage is excessive. The O'Neill series is represented in Carroll County by three soil types, the fine sand, loam, and fine sandy loam.

The surface layers of the Wabash soils are very dark grayish brown or black and have a high content of organic matter. The subsoils are heavier than the surface soils and range in color from black to very dark gray or dark grayish brown. Neither surface soil nor subsoil is calcareous. The soils of this series occur on the first bottoms of streams and are subject to overflow. The surface is level or gently sloping, and natural drainage varies from good to poor. The Wabash series is represented in Carroll County by three soil types and one phase, the silt loam, silt loam, colluvial phase, loam, and silty clay loam.

Soils of the Lamoure series are characterized by very dark grayish-brown or black surface soils and gray, drab, or mottled gray, drab, rust-brown, and yellow subsoils. The subsoils are much heavier than the surface soils, ranging from silty clay loam to clay. Soils of this series differ from those of the Wabash series in the high content of carbonates, both surface soil and subsoil commonly showing strong effervescence when treated with acid. Like the Wabash soils these soils occur on the poorly drained first bottoms that are subject to frequent overflow. The surface is flat or gently sloping, and natural drainage is deficient.

The distribution of the soils of Carroll County is shown on the map which accompanies this report. The names, acreage, and proportionate extent of the various soils are given in Table 3. A detailed discussion of each soil type and its relation to agriculture follows.

TABLE 3.—Acreage and proportionate extent of the soils mapped in Carroll County, Iowa

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Tama silt loam.....	141, 632	38. 6	Fargo silty clay loam.....	4, 288	1. 2
Carrington loam.....	71, 616	19. 5	O'Neill loam.....	3, 136	. 9
Carrington fine sandy loam.....	1, 984	. 5	O'Neill fine sandy loam.....	1, 920	. 5
Clarion loam.....	34, 496	9. 4	O'Neill fine sand.....	192	. 1
Clarion fine sandy loam.....	3, 712	1. 7	Wabash silt loam.....	25, 600	} 9. 4
Steep phase.....	2, 432		Colluvial phase.....	8, 960	
Webster silty clay loam.....	35, 264	9. 6	Wabash silty clay loam.....	3, 520	1. 0
Webster loam.....	7, 488	2. 0	Wabash loam.....	2, 176	. 6
Waukesha silt loam.....	1, 088	. 3	Lamoure silty clay loam.....	8, 640	2. 4
Bremer silt loam.....	2, 240	. 6	Pierce sandy loam.....	2, 688	. 7
Bremer silty clay loam.....	896	. 2			
Fargo silt loam.....	2, 752	. 8	Total.....	386, 720	

TAMA SILT LOAM

The following description of typical Tama silt loam refers to a soil profile observed 1 mile north and one-half mile east of Manning. The surface soil consists of finely granular very dark grayish-brown silt loam. The granules, to which the grass roots cling tenaciously, are one-sixteenth inch or less in diameter. When crushed the surface of these granules has a slightly grayish or brownish cast. The entire soil mass is filled with grass roots, forming a turf. Below this surface layer and continuing to a depth of 9 inches is very dark grayish-brown finely granular silt loam which becomes almost black when wet. When the material is broken the clods have a uniformly dark-brown color that changes to a slightly lighter shade when the clods are crushed. The mass crumbles readily into granules which average slightly larger than those of the surface layer. The third distinct layer, which is about 9 inches thick, grades in color from the very dark grayish brown of the surface into the lighter shades of the true subsoil below. The color, however, is not uniform but consists of a succession of light and dark spots, owing, no doubt, to the downward movement of the dark-colored organic matter from above through root channels and worm burrows, as well as to the transposition by animals of small amounts of light-colored material from below. The material is heavy somewhat granular silt loam. When disturbed the mass breaks down to small irregular clods which are distinctly lighter colored when crushed. This layer is more compact than the layers above. Below this the true subsoil, occurring between depths of 18 and 31 inches, consists of brown silty clay loam. The mass is structureless and breaks into irregular clods with little change in color. The worm casts are filled with dark-colored material and are slightly more numerous than in the overlying layer. The subsoil did not effervesce when treated with acid. The fifth distinct layer is brown silty clay loam faintly mottled with gray and grayish yellow. The mottling, however, does not seem to be caused by poor drainage but rather by some peculiarity of the parent material. The mass, like the layer above, is structureless and breaks into irregular-shaped lumps. A few small iron concretions and fine dark-colored pencilings were noticed. In this layer also there is no evidence of lime. The next layer, which continues to a depth ranging from 55 to 83 inches, is similar to the one above except that it is more thickly mottled with iron stains and concretions. These concretions accumulate in streaks and elongated bodies as though following root holes. Below this layer is grayish-yellow plastic silty clay loam. In the upper part of this layer the black specks and iron concretions are not so numerous; but they increase with depth, and below a depth of 142 inches become more conspicuous. The carbonates have been removed to a greater depth, and no effervescence occurred when the material of this layer was treated with dilute acid.

Practically all of this soil is under cultivation. In cultivated areas the profile differs from that described above in that the two surface layers become thoroughly mixed and range in color from dark grayish brown to very dark grayish brown when dry and to almost black when wet.

This soil is uniform throughout the area of its development. For miles in many places there are only slight variations in color. On

the more eroded areas the surface layers are shallower, whereas throughout the few undulating areas, such as those near Templeton and Breda, the dark-colored surface layer ranges from 18 to 20 inches in thickness. Included with mapped areas of this soil are very small local patches which differ from typical in that numerous lime concretions occur throughout the soil mass. Such areas are scattered throughout the western half of the county, the more conspicuous occurring in the vicinity of Carroll near the escarpment between the loess and drift. The areas were so variable and of such small total extent that separation was not considered advisable or practical.

Tama silt loam is the most extensive soil in Carroll County. It occurs only in that part of the county west of a line drawn through Breda, Carroll, and Coon Rapids, in continuous areas broken only by the deep intervening valleys which have cut through the loess into the underlying drift. The towns of Arcadia, Manning, Templeton, Halbur, Roselle, Dedham, and part of Coon Rapids are located on this soil.

The surface ranges from gently undulating to rolling, the greater part of the soil having a moderately rolling surface with well-rounded, evenly sloping hills. Surface drainage is well established, and only on the steeper slopes is the run-off excessive enough to cause serious damage through erosion. Throughout these rougher areas care should be exercised to plow at right angles to the slopes and to keep the surface covered. The subsoil is retentive of moisture, and where the soil is properly cultivated and cared for crops seldom suffer from drought.

Tama silt loam is one of the more important soils of Carroll County. Practically all of it is either under cultivation or in pasture, the only tree growth consisting of the windbreaks of evergreens, maple, cottonwood, and elm that have been set out west and north of farm dwellings.

Corn is the principal crop, and the average yield is 40 bushels to the acre. Much larger yields have been reported by the better farmers, a few obtaining 100 bushels to the acre. The greater part of this crop is used on the farms as feed for the hogs and work animals, but a small tonnage is shipped to outside markets. Oats fill an important place in the rotation on every farm and constitute the crop second in importance. During favorable years yields average between 40 and 60 bushels to the acre, and maximum yields ranging from 65 to 75 bushels have been reported. This crop is practically all used on the farms as feed. At the present time only a small acreage of wheat is grown, though a few years ago this crop was of considerable importance and occupied about two-thirds of the small-grain acreage. Barley and rye are also grown on a small scale. The barley is all fed as grain to hogs, and the rye is grown for hog pasture. Clover and timothy, the principal hay crops, give yields ranging from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre. The tendency is to increase the clover acreage and decrease that of timothy. The supply of hay is not equal to the demand, and a large tonnage of alfalfa hay is shipped into the county. Alfalfa and sweetclover are being grown more extensively, though these crops are not so popular as in the glaciated eastern sections of the county. Excellent results are obtained, however, where enough lime is used to correct the acidity

of the land. Yields ranging from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre are common, and $3\frac{1}{2}$ tons are frequently harvested. The alfalfa is cut for hay, and the sweetclover is used almost entirely for pasture. Soybeans are grown to some extent, mostly with the corn that is to be cut for silage. A few orchards were noticed, but owing to the lack of care the fruit is usually faulty. Gardens are maintained on most farms, and the surplus vegetables are sold locally.

The principal livestock industry consists of the raising and feeding of hogs and cattle. Between 50 and 60 head of hogs is the average for each farm. The hogs are either sold to buyers or are shipped through cooperative livestock associations. On most farms a carload of beef cattle is bought each year. The animals are fed from four to six months and are then resold. Dairying is at present carried on as a side line, though this industry is growing in importance. The general practice is to keep from 7 to 12 cows. A few herds of sheep were noticed, and, during bumper crop years, many sheep are shipped in from the West for fattening.

The use of commercial fertilizers is practically unknown, except on a few experimental plots. Lime is used to very good advantage, and the tonnage shipped in is increasing yearly. Barnyard manure is saved on most farms and applied to the cornland and grassland in the spring and fall before plowing.

Tama silt loam, because it is friable and mellow, can be handled by the farm methods common to this part of the State. The soil warms up earlier in the spring than the heavier soils in the eastern part of the county. Therefore, earlier planting is possible. As much of the land as possible is plowed in the fall.

Definite crop rotations are in more or less general use. The general practice is to grow corn 2 or 3 years, oats 1 year, corn 1 year, oats 1 year, and clover and timothy 1 or 2 years. On the highly improved farms a 4-year rotation consisting of corn, corn, oats, and clover is used.

Very few farms in Carroll County have changed hands recently, consequently values could be arrived at only by averaging the few sales that were made during the year of the survey. Improved farms sell at \$200 or \$225 an acre, and the more undesirable ones bring \$50 or \$60 less.

Tama silt loam is a strong agricultural soil, but unless proper methods of handling and cultivation are practiced its fertility will gradually decrease. The use of definite crop rotations in which legumes play an important part is urged. Alfalfa, especially, should be more extensively grown. The liming of the soil and the inoculation of the seed are necessary for best results. Corn and small grains should be grown on the same ground for shorter periods of time. Deeper plowing and more thorough preparation of the seed bed are also important, as such methods not only conserve moisture during dry seasons but enable the soil to absorb larger quantities of moisture without injury to the growing crop. The application of lime would no doubt prove of benefit to all crops, as the surface soils are pre-vaillingly acid.

Table 4 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of Tama silt loam.

TABLE 4.—*Mechanical analysis of Tama silt loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
336971	Surface soil, 0 to 2 inches.....	0.1	3.3	1.1	2.6	21.1	55.2	16.7
336972	Subsurface soil, 2 to 9 inches..	.1	.4	.5	3.0	20.4	57.2	18.3
336973	Subsoil, 9 to 18 inches.....	.2	.3	.3	2.0	21.0	56.1	20.0
336974	Subsoil, 18 to 31 inches.....	.0	.0	.0	.1	15.2	59.1	25.6
336975	Subsoil, 31 to 55 inches.....	.0	.0	.0	.0	19.5	61.2	19.4
336976	Subsoil, 55 to 83 inches.....	.0	.0	.0	.0	18.6	61.5	20.0
336977	Subsoil, 83 to 107 inches.....	.0	.0	.0	.0	20.0	59.7	20.3
336978	Subsoil, 107 to 142 inches.....	.0	.0	.0	.0	19.1	62.4	18.5

CARRINGTON LOAM

The following is the description of a profile of Carrington loam observed $1\frac{1}{2}$ miles due east of Carroll in section 20, T. 84 N., R. 34 W., and is representative of this soil, as developed in Carroll County. The first layer, to a depth of 2 inches, consists of dark grayish-brown loam which becomes almost black when wet. The texture is finely granular, the granules measuring from one-sixteenth to one-eighth inch in diameter. Grass roots cling tenaciously to many of these granules, forming a turf. Beneath this layer and continuing to a depth of 12 inches is a layer of very dark-brown loam that is black when wet. The mass breaks up readily into small granules, and the grass roots that penetrate this layer cling to many of them. When crushed the surface of the granules is much browner than when undisturbed. The next distinct layer, which continues to a depth of 18 inches, is a transition layer grading from very dark-brown into yellowish-brown gritty fine sandy clay loam. When the material is broken the clods are yellowish-brown spotted and streaked with dark brown or black, owing to leaching, through root channels and worm burrows, of the black organic matter from above. When broken, these clods fall apart into irregular lumps that average approximately one-sixteenth inch in diameter. When these particles are crushed the material has a uniformly yellow color. The true subsoil or heavy layer, which is yellowish-brown somewhat gritty fine sandy clay slightly spotted and specked with rust brown and yellow, underlies the transition layer. When disturbed, exposed surfaces flake off into large irregular lumps which very readily crumble into smaller irregular particles. Some iron concretions are present in this layer, and the content of fine gravel is larger than in the layer above. When crushed the surface of the lumps is yellowish brown faintly mottled with streaks of orange and black. The fifth distinct layer lying between depths of 40 and 60 inches, consists of yellowish-brown gritty sandy loam streaked and spotted with rust-brown iron stains and whitish lime-bearing materials. This layer is calcareous throughout, and the material effervesces strongly when treated with acid. Underlying this is the partly weathered parent material, which to a depth of 78 inches is yellowish-brown gritty fine sandy loam, mottled, spotted, and streaked with gray and rust brown. Black oxide of iron stains are also abundant. Between depths of 78 and 84 inches a seventh distinct layer of pale yellowish-brown silty material, containing a large quan-

tity of fine and very fine sand, is present. Mottles are less abundant than in the overlying layer, but the lime content is practically the same.

Numerous slight variations in color, texture, and thickness of the various layers, owing to local causes, occur in mapped areas of Carrington loam. Throughout the more rolling areas, on ridges, hillsides, and kames the content of fine and medium sand is highest and the color is somewhat lighter, whereas in the undulating areas the silt content is above the average and the soils are darker on account of the higher content of organic matter. The depth to the zone of lime accumulation also varies considerably. In places, the depth to lime varied so greatly even within short distances that it was difficult to determine whether the soil should be mapped with soils of the Carrington or the Clarion series. In small local pockets in the vicinity of Raccoon River the subsoil is sticky fine gravelly sand. Throughout Wheatland, Kniest, Maple River, and Pleasant Valley Townships, where the drift plain merges more gradually with the superimposed loess, the change to silt loam and the depth at which the glacial material is reached are necessarily so variable that boundaries are more or less arbitrarily drawn in some places. Included also are some narrow swales and drainage ways that would have been separated as Wabash silt loam, colluvial phase, had they been more extensive.

Carrington loam occurs in all parts of the county. Throughout the Tama silt loam areas, west of an imaginary line drawn through Breda, Carroll, and Coon Rapids, it occurs only along the lower part of the more gentle stream slopes where erosion has removed the covering of loess and exposed the underlying drift. East of this line, however, Carrington loam is extensive. Throughout Kniest, Pleasant Valley, Richland, and Union Townships the areas are large and continuous and in other parts of the county they are moderately large but isolated.

The surface of this soil varies from rolling to undulating, and drainage is well established. The subsoils are retentive of moisture, and crops seldom suffer from drought.

Carrington loam is considered a valuable agricultural soil and, except for the areas utilized for buildings, is all under cultivation or in pasture. The uncultivated areas support a luxuriant growth of grass that is excellent for grazing purposes.

The principal crops grown are corn, oats, and hay. Corn occupies by far the largest acreage, and oats ranks second. Occasionally some grain is sold within the county, though the universal practice is to use all the grain on the farms where it is produced, as feed for the work animals, beef cattle, hogs, and dairy cows. Clover and timothy are grown extensively for hay, but the supply is seldom equal to the demand. Wheat, barley, rye, rape, and soybeans are grown on a small scale. Most of the wheat is sold or traded to the flour mills within the county. The barley, rye, and rape are produced for hog feed, and the soybeans are grown with corn for silage. The acreage in alfalfa is increasing each year. Liming and inoculation are necessary to insure a good stand and stimulate growth until the roots penetrate the zone of lime accumulation. Practically

all of this crop is cut for hay. Sweetclover also is increasing in importance as a forage crop. Both the white and yellow varieties are grown. Most farmers have small gardens and grow vegetables for home use. A few small apple orchards were noticed, and cherry trees are on nearly every farm. The apple trees seldom receive any care, and the fruit is poor.

The raising and feeding of hogs and cattle are the principal live-stock industries. Some feeders are shipped into the county, especially in the vicinity of Glidden. Dairying is carried on as a side line, but the revenue derived from this source is large. The poultry industry is increasing in importance each year.

Under the prevailing methods of cultivation corn produces from 35 to 43 bushels to the acre, but much larger yields are reported on the better farms. Oats yield from 30 to 65 bushels and hay from 1½ to 2½ tons. Alfalfa is usually cut three times and produces a total of 2½ or 3 tons to the acre.

Crop rotations are practiced to some extent. On the tenant farms corn is grown for longer periods on the same piece of ground, and clovers are grown less extensively. The better farmers, however, are practicing a 4-year rotation, which consists of corn, corn, oats, and clover.

Commercial fertilizers are not used. Top-dressings of ground limestone have given excellent results, and larger quantities are applied each year. Barnyard manure is saved on most farms and scattered over the grassland and corn-stubble land before plowing.

Carrington loam is easily tilled, as it does not clod when plowed too wet nor bake on drying. The productiveness of the land is easily maintained and can be increased by the improved methods of cultivation which are in use on the better farms of the county. Although this soil warms up a little later in spring than does Tama silt loam it is earlier than the heavier-textured Webster soils.

The price of land of this kind ranges from \$190 to \$225 an acre, depending on location with reference to railroads and towns and on the condition of improvements.

The fertility of this soil can be readily increased by the use of well-planned rotations in which legumes are more extensively grown for green-manure crops. The use of lime, which is proving of much benefit, should be extended. Deeper plowing and more thorough preparation of the seed bed are also strongly recommended.

Table 5 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of Carrington loam.

TABLE 5.—*Mechanical analysis of Carrington loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
336957	Surface soil, 0 to 3 inches.....	1.8	5.5	7.3	12.3	17.5	39.5	15.9
336958	Subsurface soil, 3 to 12 inches...	1.8	5.9	7.4	12.8	15.2	38.1	18.7
336959	Subsoil, 12 to 18 inches.....	2.4	4.3	6.5	12.2	18.3	39.8	16.6
336960	Subsoil, 18 to 40 inches.....	2.8	6.1	7.7	14.2	19.2	34.6	15.5
336961	Subsoil, 40 to 60 inches.....	3.0	5.8	6.5	12.2	19.2	40.5	12.8
336962	Subsoil, 60 to 78 inches.....	2.5	6.1	7.1	13.2	19.7	34.7	16.7
336963	Subsoil, 78 to 84 inches.....	.9	2.7	4.6	10.2	23.8	43.0	14.8

CARRINGTON FINE SANDY LOAM

The surface soil of Carrington fine sandy loam is dark grayish-brown fine sandy loam, 12 or 14 inches thick, containing a high percentage of organic matter. When wet the plowed fields are very dark grayish brown or almost black. The upper part of the subsoil, which in most places is 10 inches thick, is slightly lighter-brown, heavier-textured fine sandy loam. Below this is a thin distinct layer, in most places fine sandy loam in texture and yellowish brown in color. Below a depth ranging from 50 to 60 inches the parent material, consisting of yellowish sticky fine sand, occurs. The carbonates have been thoroughly leached to a great depth, and where tested neither surface soil nor subsoil gave a reaction for lime.

Throughout the more rolling areas the color of the surface soil is not so dark, owing to the removal of the organic matter. In a few small included areas the subsoil was much lighter in texture, approaching loamy fine sand. Where Carrington fine sandy loam merges with Carrington loam the transition is gradual, and boundaries are arbitrarily drawn.

Carrington fine sandy loam occurs throughout all parts of the glaciated section of the county. With the exception of the larger areas in sections 7, 8, and 35, T. 85 N., R. 33 W., and section 2, T. 84 N., R. 33 W., this soil occurs only on small knolls and ridges. The relief is gently undulating or gently rolling. Drainage is inclined to be slightly excessive, and crops suffer during prolonged periods of drought. Practically all of the Carrington fine sandy loam is either under cultivation or in pasture. The only tree growth consists of windbreaks that have been set out to the west and north of farm dwellings. Though this is not so strong an agricultural soil as the adjoining Carrington loam, it is prized for special crops such as melons and all kinds of garden truck. Corn is the principal crop and occupies the largest acreage. Oats and hay are grown for local use. Rape is grown for hog pasture. In the vicinity of Lanesboro one farm is devoted exclusively to truck growing, and the melons and other garden truck are sold in the towns of the county.

Average yields on this soil are slightly lower than on the adjoining Carrington loam, though during wet seasons they compare favorably.

Hog raising and the raising and feeding of beef cattle are the principal livestock industries. The production of chickens and eggs is also important, and one farm located in section 5, T. 85 N., R. 33 W., is devoted entirely to this industry.

This soil can be improved in much the same manner as Carrington loam. The incorporation of green manures is strongly urged. The application of lime would also improve the physical condition of the soil and tend to increase yields. The more extensive use of this soil for the production of watermelons, cantaloupes, and all kinds of garden truck would no doubt be profitable, provided markets could be established.

CLARION LOAM

The surface soil of Clarion loam in virgin or uncultivated areas consists of very dark grayish-brown loam 1 or 2 inches thick. The texture is finely granular, and some loose silt is among the granules.

Grass roots cling tenaciously to many of the granules, forming a turf. The next distinct layer, which reaches a depth of 12 inches, contains more organic matter than the overlying layer and has a darker color, ranging from very dark grayish brown when dry to black when wet. The texture is mellow loam, and the material crumbles readily into fine granules. When undisturbed these granules have a very dark grayish-brown color, but when crushed the color of the material is brown or slightly yellowish brown. The typical subsoil is yellowish-brown fine sandy clay loam faintly streaked with dark-colored organic matter that has filtered down through old root channels and worm burrows. In the lower part of this layer some yellowish-brown or rust-brown discolorations occur. When clods are broken out they fall apart in irregular lumps. A few irregular-shaped gravel occur in the lower part of the layer, but no evidence of lime accumulation is present. The true subsoil is underlain, at a depth of 20 inches, by a fourth layer of pale-yellowish friable silty clay splotted with gray streaks and specks. The entire mass is strongly calcareous, and some soft lime concretions occur. Scattered throughout the layer is an abundance of small, nearly round gravel, and small oxide of iron specks are numerous. Beneath this layer, at a depth ranging from 50 to 70 inches, is a fifth layer of mottled yellowish-brown and gray friable silty clay, containing a few oxide of iron stains. The clods of this material crumble more readily than those in the overlying layer and fall apart in irregular granules and lumps. Below this layer and continuing to various depths is the parent material, consisting of structureless pale yellowish-brown light-textured silty material streaked and specked with gray and black. The entire mass is strongly calcareous. In cultivated areas the surface soils are predominantly dark-brown mellow friable loam.

In more rolling areas and on slopes to streams the active movement of surface waters is removing much carbonaceous material, and the surface soils are consequently lighter colored. In some areas, where the calcareous drift is within 22 inches of the surface, the yellowish-brown color of the upper subsoil layer has nearly disappeared. The zone of lime occurrence varies in depth to such an extent that in many places the separation of the Clarion from the Carrington soils was purely a matter of judgment. Owing to their small extent, areas of fine sandy loam and sandy loam are also included with Clarion loam in mapping.

The surface relief of this soil ranges from undulating to gently rolling, and drainage is sufficient for crop needs. The subsoils are retentive of moisture.

Clarion loam occurs in all parts of the county. Throughout the loess-covered, or southwest part, narrow bands of this soil occur on some of the more gentle slopes where the underlying drift has been exposed. In the northeastern part, however, the soil is extensive. The larger, more continuous areas occur in Grant, Glidden, Sheridan, and Jasper Townships.

Practically all of this soil is utilized in the production of corn, oats, and clover or for pasture. Corn occupies the largest acreage and is the most important crop. Under ordinary methods of cultivation yields average 40 bushels to the acre, but much larger yields

are obtained on the more highly improved farms. Oats rank second in importance, and yields ranging from 35 to 55 bushels to the acre are reported. All the corn and oats are used within the county as feed. Clover and alfalfa are particularly well adapted to this soil, and yields average slightly more than on the adjoining Carrington loam. Red clover produces 2 or 2½ tons to the acre and alfalfa 3 or 3½ tons. Barley, rye, wheat, and rape are also grown on small acreages. The grains are used as hog feed, and rape is sown with oats and corn for hog pasture. Sweetclover, both the white and yellow varieties, is gaining in popularity each year. This crop makes an excellent growth and is used for forage. A small acreage of Sudan grass was noticed.

The raising of hogs is the most important livestock industry. During average years a carload is shipped from each farm. The raising and feeding of beef cattle are of more or less importance, and dairying is carried on as a side line.

Commercial fertilizers are not used. Barnyard manure is saved by most farmers and is scattered over the corn-stubble land and grassland before plowing.

Clarion loam varies somewhat in price, depending on its location and the condition of farm improvements. The more highly improved farms sell for \$200 or \$225 an acre, and unimproved land commands from \$25 to \$60 less an acre.

Clarion loam is a strong agricultural soil, well adapted to the production of all staple crops common to this section of the country. Its fertility may be increased and maintained by practically the same methods recommended for the improvement of Carrington loam. The soil is particularly suited to the growing of legumes, and the acreage in these crops should be greatly increased.

Table 6 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and four layers of the subsoil of Clarion loam.

TABLE 6.—*Mechanical analysis of Clarion loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		<i>Per cent</i>						
336965	Surface soil, 0 to 2 inches.....	3.2	4.4	6.0	11.0	18.5	35.1	21.8
336966	Subsurface soil, 2 to 12 inches..	1.9	5.0	6.4	11.7	18.3	39.3	17.5
336967	Subsoil, 12 to 20 inches.....	.9	2.8	3.9	7.7	20.0	51.9	12.7
336968	Subsoil, 20 to 50 inches.....	3.3	6.5	6.8	10.9	20.0	37.7	14.7
336969	Subsoil, 50 to 70 inches.....	.4	.7	1.1	2.2	13.7	58.1	23.8
336970	Subsoil, 70 to 90 inches.....	.0	.1	.2	.9	31.0	60.6	7.2

CLARION FINE SANDY LOAM

The surface soil of Clarion fine sandy loam is dark grayish-brown fine sandy loam 8 inches thick. When wet this soil is almost black. The upper subsoil layer which continues to a depth of 20 inches is brown or yellowish-brown heavy fine sandy loam or sandy clay loam. However, owing to the presence of streaks and tongues of dark organic matter that have penetrated downward from the surface soil through old root holes and insect burrows, the color of this layer is not uniform. The third distinct layer is about 12 inches thick and consists of yellowish-brown or grayish-brown sandy clay. Some fine

gravel, which gives the mass a slightly gritty feel, occurs in the lower part. This layer is strongly calcareous. Below a depth of 42 inches and continuing to a depth varying from 4 to 5 feet is the strongly calcareous parent material. It has much the same color as the layer above but is spotted with gray and streaked with whitish tongues of carbonaceous material. The content of fine and large gravel is large and increases with depth.

Clarion fine sandy loam occurs only in the northeast half of the county as low ridges bordering some of the stream slopes or as low knolls within areas of Clarion loam. The more extensive areas are in the northeastern parts of Sheridan and Jasper Townships.

Practically all of this soil is under cultivation to the staple farm crops. Corn, which is the principal crop, occupies the largest acreage. Oats are grown on most farms. Clover, alfalfa, timothy, and sweetclover also do well. Clover and timothy are always grown together, though less timothy is grown now than formerly. Alfalfa is grown for hay, and sweetclover is a forage crop.

Yields on this soil are slightly lower than those obtained on Clarion loam. Corn yields from 35 to 40 bushels to the acre, oats from 40 to 55 bushels, clover and timothy hay from 1½ to 2 tons, and alfalfa from 2 to 3 tons.

Commercial fertilizers are not used, and barnyard manure is seldom applied as it is scarce.

Improved land of this kind is always sold with the adjoining Clarion loam and Carrington loam. Its value is slightly less than that of either of these soils.

Clarion fine sandy loam, steep phase.—The steep phase of Clarion fine sandy loam occupies the steeper more eroded slopes bordering Raccoon River and Purgatory Creek. Its total area is small.

The surface soil, which is about 7 inches thick, contains less organic matter than typical and its color ranges from dark grayish brown to very dark grayish brown. The material is loose fine sandy loam. The subsoil consists of yellowish-brown or grayish-brown gritty sandy clay which in most places effervesces when treated with acid. Fragments of the parent rock, which increase in number with depth, occur in the surface soil. Some small bowlders are embedded in the soil. Textural variations are numerous, owing to the topographic position of this soil, but separation into various phases was deemed unnecessary on account of the small extent and low agricultural value of the included areas.

Areas of this soil are too steep for cultivation and are left in their natural condition and utilized for pasturing cattle. The scattered tree growth, which covers some of the hillsides, consists chiefly of bur oak, red oak, walnut, and maple.

WEBSTER SILTY CLAY LOAM

The surface soil of Webster silty clay loam consists of black friable silty clay loam 6 inches thick. It is high in organic matter and breaks into a finely granular mass. The subsurface layer, to a depth of 10 inches, resembles the surface soil except that it contains a higher percentage of fine sand. The upper subsoil layer, which averages 14 inches in thickness, is very dark grayish-brown gritty clay. This layer merges rather gradually, at a depth

of 24 inches, into a fourth layer, which continues to a depth of 40 inches. This layer consists of grayish-yellow gritty clay mottled with rust brown. A few vertical streaks of dark carbonaceous material have filtered down into this zone through cracks, old root channels, and worm burrows. Scattered throughout the lower part are some fragments of the parent till. The mass effervesces when treated with acid. Beginning at a depth of 40 inches and continuing below the 60-inch depth is the parent material of whitish-gray gritty silty clay spotted with yellow, rust brown, and white. A few dull-red partly decomposed iron concretions occur, and the percentage of subangular rock fragments increases with depth. This material is strongly calcareous.

Variations within this soil are of minor importance. In some areas the surface soil varies in texture from clay loam to silty clay loam. Some small spots of loam that could not have been shown on the soil map without exaggeration are also included.

Webster silty clay loam occurs only in that part of the county lying northeast of a line drawn through Breda, Carroll, and Coon Rapids. It occurs both as large and small irregular-shaped areas within areas of the Carrington and Clarion soils and is mapped along the headwaters of drainage ways and in flats and depressions. Natural drainage is defective, but the greater part of the land is tilled.

Approximately 90 per cent of this soil is under cultivation or in pasture. Corn, oats, clover, and timothy are the principal crops grown, ranking in acreage in the order named. During favorable years corn produces from 35 to 55 bushels to the acre, though much larger yields are reported by the better farmers. Oats are grown on all farms. Formerly the oat crop was often damaged by lodging, but by the use of the Iowar, Albion (Iowa 103), and Richland (Iowa 105) strains, which are adapted to very fertile soils, yields have been greatly improved. The yield ranges from 35 to 50 bushels to the acre. All the corn and oats are used within the county. Red clover is the variety of clover which thrives best on this soil, and a large acreage is grown. In some places timothy is sown with the oats and remains on the land a year or two for hay. The hay crop averages 2 tons to the acre. Neither alfalfa nor sweetclover does well on this soil, no doubt on account of poor drainage conditions during the greater part of the growing season. Rye, buckwheat, and Sudan grass are produced in a small way as catch crops.

Webster silty clay loam can be improved by the incorporation of green-manure crops. As drainage is defective, many of the larger areas would be benefited by a better system of tile drainage, in which the tiles are laid closer together.

WEBSTER LOAM

The surface soil of Webster loam, in virgin or grass-covered areas which apparently have never been disturbed, consists of very dark grayish-brown finely granular loam an inch or two thick, underlain to a depth of 6 inches by a layer which is much darker in color but of similar texture. Here the content of organic matter is much higher than in the surface layer, a condition that masks the texture to some extent. The next distinct layer, which continues to a depth of 12

inches, consists of very dark-brown or black silty clay loam containing a high percentage of fine sand. This layer has a somewhat cloddy structure and is rather compact and heavy. Below this is the fourth layer, which extends to a depth of 20 inches below the surface. It is lighter colored than the overlying layer, being dark grayish brown, and is slightly heavier. Underlying this to a depth of 36 inches is a fifth layer of dark grayish-brown slightly gritty clay splotted and streaked with gray, yellowish brown, and yellow. Below this layer is the parent material which is mottled gray, brown, yellowish-brown, and rust-brown sandy clay loam. Medium-sized and small fragments of the parent rock occur from the surface downward and increase in number with depth. Much of the parent material contains enough calcium carbonate to effervesce freely when treated with acid. Cultivated areas, which constitute approximately 96 per cent of the total acreage, differ from the virgin soil in that the two upper layers become thoroughly mixed and give to plowed fields an intense dark grayish-brown or almost black appearance.

Webster loam, like Webster silty clay loam, occurs only in the northeast half of the county, principally throughout the smaller depressed areas or as narrow ribbonlike strips bordering the larger silty clay loam areas. In some places it lies between Webster silty clay loam and the Carrington or Clarion soils.

Natural drainage is somewhat better established than on Webster silty clay loam, but it is inadequate for crop needs. Much of the land, however, has been tiled, and crops seldom suffer except during prolonged wet periods.

Practically all of the Webster loam is under cultivation to corn, oats, clover, and timothy. The crops are handled in much the same way as on the adjoining Webster silty clay loam, and yields are practically the same. Corn yields from 35 to 55 bushels to the acre, oats from 38 to 50 bushels, and clover and timothy from 1½ to 2½ tons of hay. Owing to inadequate drainage during part of the growing season, alfalfa is seldom grown.

When sold Webster loam is generally included with Webster silty clay loam, Carrington loam, or Clarion loam. Its value ranges from \$175 to \$200 an acre, depending on the condition of the improvements and the location with reference to towns and railroads.

WAUKESHA SILT LOAM

The surface soil of Waukesha silt loam in virgin or uncultivated areas consists of dark grayish-brown fine granular silt loam 2 or 3 inches thick. The granules are small, measuring from one sixty-fourth to one-sixteenth inch in diameter. The grass roots which fill this layer cling tenaciously to many of the granules, forming a turf. When crushed the mass has a yellowish-brown cast. The next distinct layer, which continues to a depth ranging from 2 to 18 inches, is very dark grayish-brown mellow loam. When disturbed the lumps fall apart readily into granules which are somewhat larger than in the overlying layer. The true subsoil is yellowish-brown friable and crumbly sandy clay faintly streaked with dark-colored material where the organic materials from above have percolated downward through old root channels and worm burrows. Underlying this layer,

at a depth of 40 inches and continuing to a depth of 50 inches, is a fourth layer consisting of brownish-yellow light sandy clay loam. Iron concretions and rust-brown stains increase with depth. This layer grades into pale brownish-yellow loamy fine sand, in which the content of fine sand increases below the 65-inch depth. In cultivated areas the two upper layers become so thoroughly mixed that plowed fields assume a dark grayish-brown or very dark grayish-brown color.

Areas of this soil are uniform in both color and texture, with the exception of a few very small patches in sections 17 and 18 of Jasper Township, where the texture approaches loam.

Waukesha silt loam occurs on the second terraces of Raccoon River, Middle Raccoon River, and Brushy Fork Creek. It occupies a position from 3 to 5 feet above the level of the first bottoms and from 8 to 15 feet above the level of the streams. The surface is level, but drainage is good.

Practically all of this soil is under cultivation or is in pasture. Corn, small grain, and hay are the principal crops. Corn occupies the largest acreage. Crop yields compare favorably with those obtained on Carrington loam. Corn yields from 35 to 45 bushels to the acre, oats from 30 to 55 bushels, and hay from 1½ to 2 tons. Practically all the grain and hay are used on the farms where raised as feed for work animals, beef cattle, and hogs.

Waukesha silt loam is highly prized on account of its natural fertility and adaptability to the production of all the staple crops grown in Carroll County. Farming operations are practically identical with those used on the Carrington and Tama soils of the uplands.

The value of Waukesha silt loam is the same as that of Carrington loam, depending on location and condition of improvements.

BREMER SILT LOAM

The surface soil of Bremer silt loam is very dark grayish-brown mellow silt loam from 9 to 12 inches thick. The subsoil is black silty clay loam which is underlain, at a depth of 20 inches, by a third distinct layer, consisting of very dark grayish-brown or dark grayish-brown gritty clay. Some variations occur in mapped areas of this soil, the more conspicuous being found along the east side of Raccoon River in sections 1 and 2, T. 84 N., R. 33 W.

Bremer silt loam is inextensive. It occurs along the rivers and larger creeks of the county as small, more or less isolated areas. The most extensive areas are on the terraces of Raccoon River.

This soil is well above the reach of ordinary overflow and even though it is flat or very gently sloping toward the streams, drainage is sufficient for crop needs. Practically all of it is under cultivation to corn, oats, and hay or is in pasture.

BREMER SILTY CLAY LOAM

The surface soil of Bremer silty clay loam is very dark grayish-brown or almost black friable silty clay loam, 10 or 12 inches thick. This is underlain by dark grayish-brown or dark brownish-gray silty clay from 8 to 15 inches thick, and this in turn by dark steel-

gray or dark brownish-gray silty clay mottled with dark gray and rust brown.

This soil occurs in small isolated areas throughout the second terraces of the rivers and larger creeks of the county. The larger more connected areas are just south of Coon Rapids and in the extreme northeast corner of the county along Raccoon River.

The surface of Bremer silty clay loam is flat or very gently sloping, and the soil lies from 10 to 15 feet above the normal stream level. Drainage in most places is adequate and crops seldom suffer from an excess of water except during prolonged periods of high water.

Bremer silty clay loam is considered valuable for the production of corn, and practically all of it is devoted to this crop. Yields of 40 and 50 bushels are common. Bluegrass and native grasses make a luxuriant growth. Most of the grass areas are used for pasture, though some hay is harvested.

FARGO SILT LOAM

The surface soil of Fargo silt loam consists of black mellow silt loam containing a high percentage of organic matter and some fine and medium sand. This is underlain by the black silty clay loam subsoil, which is about 8 inches thick. Beneath this layer is mottled gray, yellowish-brown, and brown gritty clay. All three of the above layers are calcareous, the content of lime increasing with depth. Near a depth of 40 inches there are generally some soft lime concretions. In section 30 of Richland Township and sections 5, 6, and 8 of Union Township two areas of approximately 80 acres each resemble muck but are included with this soil in mapping. These areas differ from typical Fargo silt loam in that the surface soil, to a depth of 12 or 14 inches, is black, light, fluffy, smooth silt containing many small shells. Drainage is not well established and in some places the surface is still covered with a luxuriant growth of water-loving plants. Such areas are indicated on the map by swamp symbols.

Fargo silt loam occupies old lake and stream terraces where the weathering of the reworked materials under poor drainage conditions has given rise to the present soils. Unlike the Webster soils this soil is free of bowlders and glacial till. The surface is level, and the soil occupies depressions or basinlike areas which receive the seepage from the surrounding soils. Natural drainage is poor, and tiling and ditching are necessary. The more extensive areas of this soil occur in the southeast quarter of the county in the vicinity of Carrollton, and two small areas lie east and west of Breda in the northwestern part.

Approximately 40 per cent of the total acreage is in cultivation. Corn is practically the only crop grown and excellent yields, ranging from 40 to 60 bushels to the acre, are obtained. Oats are grown to some extent but are so severely damaged by lodging that the crop is not profitable. Native grasses make an excellent growth and on many farms they are cut for hay, commonly producing $1\frac{1}{2}$ or 2 tons to the acre. After the hay has been harvested livestock is usually pastured in the fields until the cornfields are available.

FARGO SILTY CLAY LOAM

The surface soil of Fargo silty clay loam consists of black or very dark grayish-brown friable silty clay loam, 10 or 12 inches thick, containing a high percentage of organic matter and some small shells. The subsoil, to a depth of 18 or 20 inches, is black silty clay. This is underlain, to a depth of 40 or 45 inches, by mottled gray, rust-brown, yellowish-brown, and brown heavy silty clay. Both surface soil and subsoil are rich in lime, the zone of greatest concentration occurring between depths of 10 and 20 inches below the surface.

Like Fargo silt loam, Fargo silty clay loam occupies old lake and stream basins and has been formed from reworked materials that have been transported from the surrounding uplands. Natural drainage is poor, owing to the seepage from the surrounding high ground, and water stands on the surface for long periods after rains unless the land is tilled or ditched. This soil occurs only in the glaciated parts of the county, the more extensive areas being in the southeast quarter in the vicinity of Carrollton and Coon Rapids.

Fargo silty clay loam is considered a valuable soil for the production of corn, and the well-drained areas are devoted exclusively to this crop. Wild grasses make a luxuriant growth and in some places are cut for hay, but the greater acreage is devoted to pasture.

This soil can be improved by the construction of open ditches and by tiling. It is naturally very fertile and, where the drainage waters are controlled, it can be made a valuable soil for the production of all crops adapted to this region.

O'NEILL LOAM

The surface soil of O'Neill loam, to a depth of 14 inches, is dark grayish-brown or almost black mellow loam containing a large amount of organic matter. The subsoil, extending to a depth of 20 inches, is brown gritty sandy loam. This layer grades into sticky sand which contains some clay and which, in turn, is underlain, to a depth of 24 inches, by yellowish-brown or yellowish loose fine sand, containing some fine gravel. This layer, at a depth of 40 inches, passes into yellowish coarse sand which contains some nearly round fine gravel. The subsoil shows no trace of carbonates.

Areas of O'Neill loam are fairly uniform in color, texture, and profile characteristics, except in three very small areas along Willow Creek in sections 11, 14, and 24 of Richland Township. These areas differ from the typical soil in that the sand and gravel substratum shows moderate effervescence when treated with acid.

O'Neill loam occurs in all parts of the county except the southwest quarter, in more or less isolated areas throughout the second terraces of the rivers and creeks. The largest area is along Spring Branch in Pleasant Valley Township. The surface is level and lies from 10 to 15 feet above the normal water level of the rivers and from 6 to 8 feet above that of the creeks.

Owing to the sand and gravel substratum, drainage in most places is excessive, although in a few places where the content of organic matter is highest the surface and subsurface soils are moderately retentive of moisture.

Practically all this soil is under cultivation, principally to corn which yields from 25 to 33 bushels to the acre. Oats are grown in most rotations and produce from 25 to 35 bushels to the acre. Timothy and clover constitute the chief hay crop, and during normal years 1 or 1½ tons of hay to the acre are produced. All the grain and hay are used for feed on the farms where they are produced.

O'Neill loam is handled in much the same manner as the upland soils, Tama silt loam and Carrington loam. It can, however, be plowed under much wider moisture conditions. All available manure is used on the corn-stubble land and clover land.

This soil is droughty. Legumes, which do well, should be more extensively grown. Liming and inoculation, however, are necessary for best results. Green-manure crops should be plowed under from time to time, and where this is done corn gives larger yields.

O'NEILL FINE SANDY LOAM

The surface soil of O'Neill fine sandy loam consists of dark grayish-brown fine sandy loam 10 inches thick. This is underlain, to a depth of 24 inches, by yellowish-brown gritty sandy clay containing some rounded fine gravel. This layer, in turn, grades into a third distinct layer of somewhat sticky yellow fine sand. As in the overlying layer rounded fine gravel occur in varying quantities.

This soil shows some variations in texture, ranging from very fine sandy loam to sandy loam. Along the Greene County line where it joins an area of sandy loam in that county the texture is somewhat coarser. However, on account of the small area involved, it was not deemed necessary or advisable to establish another soil type.

O'Neill fine sandy loam, like O'Neill loam, occurs only in the eastern half of the county, mainly in the northeastern quarter. The more extensive areas are along Raccoon River and Purgatory Creek and on the terraces of Middle Raccoon River. The town of Coon Rapids is located partly on this soil.

Areas of this soil occupy slightly higher positions than the loam areas, and drainage is excessive. Crops suffer from drought, except during wet seasons.

O'Neill fine sandy loam is low in natural fertility, but in spite of this fact practically all of it is under cultivation or is devoted to pasture. Corn occupies the largest cultivated acreage, with oats and hay following in the order named. Corn yields from 25 to 30 bushels to the acre, oats from 25 to 38 bushels, and hay about 1 ton. Farming practices are the same as on the major upland soils. The soil is droughty, and crops often fire. Legumes, including alfalfa and sweetclover, seem to make very good growth provided the seed is inoculated and the soil limed.

It is strongly recommended that a larger acreage of this soil be devoted to the production of legumes and less to corn. Green-manure crops should also be more extensively grown. Such a practice will improve the physical condition of the soil and add to its moisture-holding capacity. Melons and garden truck could no doubt be profitably grown.

O'NEILL FINE SAND

O'Neill fine sand consists of a surface layer of brown or medium dark-brown fine sand or loamy fine sand, from 6 to 8 inches thick. This is underlain by a dark-brown fine sand layer, 16 inches thick, which is more incoherent than the surface soil but which contains a higher percentage of colloidal organic material. Beneath this layer is yellowish-brown or yellowish loose-textured fine sand that reaches a depth of 42 or more inches without change. Neither surface soil nor subsoil is calcareous. The soil is rather uniform throughout Carroll County.

O'Neill fine sand occupies a small total acreage and occurs in association with the loam member of the O'Neill series, usually occupying small knolls and elongated low ridges. The surface is undulating or gently rolling, and drainage is excessive.

Owing to its low fertility and droughtiness, very little of this soil is under cultivation. It is left in its virgin condition and utilized for pasture. The only tree growth consists of a few willows along old fence rows. Native grasses make a poor or indifferent growth.

WABASH SILT LOAM

The surface soil of Wabash silt loam consists of very dark grayish-brown even-textured silt loam, 10 or 12 inches thick. The subsoil, to a depth of 24 inches, is dark-gray silty clay loam faintly spotted with darker colors where the organic materials have percolated downward through cracks, old root channels, and worm burrows. This layer is underlain by very dark-brown or black silty clay slightly spotted with dark rust brown and yellowish brown. A few iron stains and concretions also occur.

Like all first-bottom or overflow soils, this soil is more or less variable. Throughout the southwestern half, or loessial section, of the county the surface layer is in most areas slightly lighter colored, the color becoming darker with depth. In some areas alternating light-colored and dark-colored bands or layers 2 or 3 inches thick are found at a depth varying from 4 to 8 inches. In many places along Raccoon and Middle Raccoon Rivers the subsoils are variable, having a stratified appearance caused by the presence of successive layers of dark-gray sand and black heavy material. Included with Wabash silt loam are some areas, too small to show on the map, of the loam and silty clay loam members of the Wabash series.

Wabash silt loam occurs along all the rivers and creeks of the county. The more extensive areas lie along the Middle Raccoon and West Nishnabotna Rivers, Spring Branch, and Brushy Fork Creek. The surface is level or very gently sloping toward the streams, and the land is poorly drained except where it lies 8 or 10 feet above the normal water level and is well tilled. Many of the rivers and creeks have been dredged and straightened, bringing about a great improvement in internal drainage conditions.

Wabash silt loam is considered a strong agricultural soil and throughout areas in which the water table has been sufficiently lowered it is valuable for the production of all the staple crops. Corn occupies by far the largest acreage and, on the better farms, pro-

duces from 50 to 70 bushels to the acre. Oats are not so extensively grown, on account of the danger of lodging. However, this danger is overcome, to a marked degree, by the use of the Iowar, Richland, and Albion oat varieties, which are adapted to soils of high natural fertility. The greater part of this soil is left in its natural state and is used for pasturing the work animals, beef cattle, and milk cows. A small acreage is cut for hay. In some places bluegrass makes an excellent growth.

Wabash silt loam is handled in much the same way as Tama silt loam and Carrington loam of the uplands. It does not, however, dry out so readily. Planting is a little later in the spring and greater care is exercised to plow under the proper moisture conditions. Commercial fertilizers, lime, and barnyard manure are not used on this soil.

Wabash silt loam is always sold with the adjoining upland soils. Its value is less than that of Carrington loam.

Soils of this type, when well tilled and protected from overflow, are considered valuable for the production of corn.

Wabash silt loam, colluvial phase.—Wabash silt loam, colluvial phase, consists of dark-brown or brown mellow silt loam from 12 to 18 inches thick, underlain by slightly darker-brown silt loam. In some areas the dark-brown mellow silt loam continues to a depth of 3 or more feet without change either in color or texture. On account of their small extent some narrow areas of typical Wabash silt loam are included with mapped areas of this soil.

Soil of this phase occurs only in the southwestern or loess-covered half of the county. It lies along the smaller intermittent drainage ways. The surface is flat or gently sloping and in most areas lies from 2 to 4 feet above the bottoms of the stream channels. The soil is subject to overflow, but water seldom remains on it for any length of time. In a few areas drainage is sufficient, but as a whole it is poor.

Only a very small part of this soil is under cultivation, the greater part, approximately 90 per cent, remaining in its natural state. The uncultivated areas support a rank growth of weeds and native grasses which serve as pasture. The few cultivated areas are farmed in conjunction with Tama silt loam and receive the same treatment, though yields are slightly higher.

The straightening of the drainage ways and the laying of lateral tiles will increase the productivity of this soil.

WABASH SILTY CLAY LOAM

The surface soil of Wabash silty clay loam consists of black silty clay loam rich in organic matter. The subsoil consists of a very dark-brown heavy silty clay layer underlain, at a depth of 18 inches, by dark olive-drab heavy clay. Faint rust-brown mottles and iron stains, which increase in number with depth, are present in this layer. At a depth of 38 inches light grayish-yellow friable silty clay containing some small black concretions and mottles of rust brown, gray, and yellow is present. The concretions vary in size from one sixty-fourth to one thirty-second inch in diameter.

Wabash silty clay loam occurs only in the northeast quarter of the county, throughout the first bottoms of Middle Raccoon River, Storm Creek, and some of the smaller drainage ways. The largest area occurs along Middle Raccoon River in the southern half of Grant Township, where the bottoms reach a width of 2 miles.

The surface is practically flat, and the soil occupies a position from 10 to 15 feet above the normal level of the rivers and from 5 to 8 feet above that of the creeks. Natural drainage is insufficient for crop needs. The dredging and straightening of many of the river and creek channels have improved drainage conditions. Throughout such areas overflows are rare, and when they do occur water remains on the land for only a short period of time.

Approximately 85 per cent of this soil is under cultivation or is in pasture. Corn is the most important crop and occupies the largest acreage. Oats rank second and hay third. All the grain and hay is used on the farms of the county as feed for the work animals, milk cows, and beef cattle. The uncultivated areas are left fallow and utilized for pasture. Natural grasses and bluegrass thrive. The livestock industries consist of the raising of hogs, the raising and feeding of some beef cattle, and, to a small extent, dairying. No special crops are grown.

Corn yields from 40 to 45 bushels to the acre, oats from 33 to 35 bushels, and hay from 1½ to 2½ tons.

Wabash silty clay loam is handled in much the same manner as the adjoining Carrington loam of the uplands. The rotations differ only in that corn is grown for longer periods on the same piece of ground without decrease in yields. This soil is naturally productive and seldom receives any fertilization.

Land of this kind is valued at prices ranging from \$150 to \$200 an acre, depending on location and the condition of improvements.

Drainage is of the greatest importance, and considerable care should be given to this problem. Many of the streams have already been straightened, and lateral tiles have been laid. In this way, drainage has been greatly improved, but drainage operations should be extended. Owing to the compactness of the subsoils, the laterals should be placed closer than in lighter-textured soils. The incorporation of green-manure crops will also loosen up the surface soils and improve their physical condition.

WABASH LOAM

Wabash loam, to a depth of 20 inches, consists of dark grayish-brown or black mellow loam. The subsoil, to a depth of 40 inches, is dark grayish-brown clay loam. Both surface soil and subsoil are slightly acid. With each overflow new materials are added, and both surface soil and subsoil appear slightly stratified in some places. Included with mapped areas of this soil are a few areas of fine sandy loam and fine sand which were too small to separate.

Wabash loam occurs only in the northeastern quarter of the county, as comparatively narrow strips of bottom land along Raccoon River and Purgatory Creek. The areas along the river average a quarter of a mile in width. All the land is subject to overflow, and the surface appears uneven. Drainage ranges from good to poor.

Practically all this soil is left in its natural state and used for pasture. The tree growth consists chiefly of elm, willow, poplar, hard maple, and walnut. Clumps of gooseberry bushes are found, and wild grasses and bluegrass make a rather indifferent growth.

LAMOURE SILTY CLAY LOAM

The surface soil of Lamoure silty clay loam, to a depth of 10 inches, consists of very dark grayish-brown or black mellow silty clay loam containing a large proportion of organic matter. Fragments of shells occur both on the surface and throughout the surface layer. The subsoil, to a depth of 20 inches, is black silty clay mottled and streaked with whitish carbonaceous materials and yellow stains. Beneath this and continuing to varying depths is a third distinct layer consisting of black or dark grayish-black silty clay mottled with rust brown, gray, and yellow. The two upper layers are strongly calcareous, but the lime content seems to decrease somewhat in the lower part of the third layer. This soil is remarkably uniform throughout its occurrence, the only variations being a few areas of silt loam so small and of such slight difference that separation was not deemed necessary.

Lamoure silty clay loam is extensive along Middle Raccoon River, Storm Creek, and Willow Creek. The most extensive areas, which reach a width of 2 or 3 miles, occur in the bottoms just north and south of the confluence of Middle Raccoon River and Storm Creek.

The surface is level and is from 8 to 10 feet above the normal level of the river and from 2 to 3 feet above that of the creeks. The land is subject to overflow, but where the streams have been ditched and straightened the water seldom remains on the surface for any length of time. Throughout the bottoms of Middle Raccoon River and Storm Creek, where sufficient tiles have been laid, drainage is adequate for crop needs during normal years. In other areas, especially along Willow Creek, where drainage is poor, the areas present a swampy appearance and are covered with a dense growth of water-loving plants.

Approximately 85 per cent of this soil has been reclaimed and placed under cultivation. The more extensive, higher areas are devoted exclusively to the production of corn, whereas the more poorly drained areas are used for pasture. During favorable seasons corn yields range from 45 to 60 bushels to the acre.

Land of this kind is handled in practically the same manner as the adjoining Wabash silty clay loam, and the methods suggested for the improvement of that soil can be equally well applied to Lamoure silty clay loam.

PIERCE SANDY LOAM

The surface soil of Pierce sandy loam, to a depth of 6 inches, is very dark grayish-brown medium sandy loam which contains some coarse material. The upper subsoil layer consists of yellowish-brown loose-textured sandy loam or loam which is, in turn, underlain, at a depth ranging from 12 to 18 inches, by stratified beds of sand and

gravel. Below a depth of 24 inches the gravel, in most places, effervesces when treated with acid.

Pierce sandy loam is of small total extent and occurs only in the glaciated sections of the county as kames and eskers. Some of the areas are too small to show on the soil map and others comprise as much as a half section of land. The most extensive area lies along the east side of Purgatory Creek in sections 25 and 36 of Jasper Township. The surface ranges from rolling to hilly, and drainage is excessive.

Areas of this soil are cultivated only in conjunction with the adjoining Carrington and Clarion soils. Such cultivated areas present a splotched appearance when viewed from a distance. Crop yields are much lower than on the heavier Carrington and Clarion soils. The larger areas are usually left in pasture.

SUMMARY

Carroll County is in the west-central part of Iowa and has an area of 573 square miles.

The county lies about equally within the glaciated and loessial parts of the State, a line drawn through Breda, Carroll, and Coon Rapids forming the line of demarcation. The surface features of the southwest half are those of a rolling plain, whereas the glaciated section is predominantly flat or gently undulating.

The county ranges in elevation above sea level from 1,570 feet in the west-central part to 1,100 feet in the northeastern part. The prevailing slope is toward the southeast.

Carroll County is drained largely by Raccoon and Middle Raccoon Rivers and their tributaries. A small area in the southwest quarter is drained by West Nishnabotna River. Throughout the southwestern half the drainage is sufficient, but in the eastern part of the county many low areas require artificial drainage.

According to the United States census report for 1920 the population consists of 21,549 persons, chiefly of native parentage.

Carroll, located near the center of the county, is the county seat and principal town. Many smaller towns and villages afford excellent trading facilities.

The railroad service is excellent. Three railroad systems, the Chicago & North Western, Chicago, Milwaukee & St. Paul, and Chicago Great Western afford very good shipping facilities for all farms of the county.

The highway system is much above the average. Most of the roads have been brought to grade and a large total mileage is graveled.

The climate is favorable for the production of all staple crops. The average frost-free season is 154 days. The mean annual precipitation is 31.6 inches.

The agriculture of Carroll County consists of the growing of grain and hay and the raising and feeding of livestock. Corn is the principal crop and all farming operations are centered around its production. The livestock industries consist of the raising of hogs, the raising and feeding of beef cattle, and, to a small extent, of dairying.

The soils are predominantly dark colored and have been derived from two different underlying materials, the Wisconsin drift and the Missouri loess. They have been formed under the influence of a luxuriant grass vegetation, which accounts for many of their present characteristics. Twenty soil types and two soil phases have been mapped.

Carrington loam and Carrington fine sandy loam are dark-colored soils of glacial origin. The loam, which covers a large total area, is considered a valuable soil for the production of all crops. The fine sandy loam is less valuable and is best adapted to the growing of truck crops and melons.

Tama silt loam, which covers approximately two-fifths of the county, is derived from the silty material commonly called loess. This soil is well drained and fertile.

Webster silty clay loam and Webster loam are dark-colored soils rich in organic matter. They are of glacial origin and occupy the more undulating and flat areas. Drainage is deficient, and tiling is necessary for best results. These soils, where well drained, are valuable and productive.

Clarion loam and Clarion fine sandy loam are dark-colored soils which resemble the Carrington soils in surface and subsurface characteristics. They differ in that the lower part of the subsoils is calcareous. Clarion fine sandy loam, steep phase, has much the same profile as the typical soil, but the areas are much steeper.

Pierce sandy loam is a dark-colored gravelly glacial soil, occurring on gravel hills and ridges.

Waukesha silt loam is a dark-colored terrace soil and is valuable for the production of corn, oats, and hay.

Bremer silt loam and Bremer silty clay loam have dark-colored surface soils and dark grayish-brown or dark olive-drab subsoils. These soils occur on terraces but are not so well drained as the Waukesha soils. They are naturally very productive.

Fargo silt loam and Fargo silty clay loam consist of dark-brown or very dark grayish-brown surface soils underlain by dark-drab or mottled subsoils. Both surface soil and subsoil are calcareous. They occur on the more poorly drained second terraces and old lake basins. Where these soils are well drained and tilled they produce excellent crops of corn.

O'Neill loam and O'Neill fine sandy loam are dark-colored terrace soils underlain, at a depth ranging from 20 to 24 inches, by beds of stratified sand and gravel. These soils are less productive than the Waukesha soils.

Wabash silt loam, Wabash silt loam, colluvial phase, Wabash loam, and Wabash silty clay loam are dark-brown or black first-bottom soils extensively used for pasture. Where artificially drained, however, they are valuable for the production of corn.

Lamoure silty clay loam is a very dark-brown or black heavy-textured bottom-land soil that differs from Wabash silty clay loam mainly in that the surface soil and subsoil are calcareous. Natural drainage is deficient, but much of the soil has been reclaimed by ditching and tiling. Throughout such areas corn is the principal crop. The uncultivated areas are used for pasture.

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