SOIL SURVEY OF CLAY COUNTY, IOWA.

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DESCRIPTION OF THE AREA.

Clay County lies in the northwestern part of Iowa, one tier of counties separating it from the State of Minnesota and two lying between it and the State of South Dakota. Its southwestern corner is about 60 miles northeast of Sioux City, the second largest city in the State. It is bounded on the north by Dickinson County, on the east by Palo Alto County, on the south by Buena Vista County, and on the west by O'Brien County. It is practically square, and has an area of 563 square miles, or 360,320 acres.

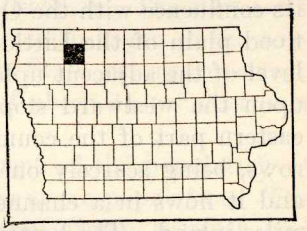

FIG. 48.—Sketch map showing location of the Clay County area, Iowa.

The surface of Clay County was originally that of an undulating, drift-covered plain, and the present relief is mainly the result of erosion, which has been more pronounced along the streams in the southern half, where the surface is prevailingly gently rolling. Most of the upland throughout the county, however, lies nearly flat or gently undulating. Small morainic hills or Knolls occur in places in the eastern part of the county, in the lake region, but a typical morainic topography is not developed as in the counties to the east and north.

In general, the slopes along the larger streams are gently rolling. The upland along Elk Creek and in the immediate vicinity of the Little Sioux River, in the southern half of the county, is more strongly rolling, the streams having cut more deeply into the drift. Elsewhere the descent to the alluvial lands is gradual.

The alluvial lands along the streams include old high terraces, now standing above the level of ordinary floods, and the first bottoms or present flood plains, practically all subject to frequent overflow. High terraces occur irregularly along the larger streams in all parts of the county. They are most extensive along the Little Sioux and Ocheyedan Rivers. These benchlike areas show little surface relief except where cut by streams issuing from the adjoining upland.

First bottoms occur along nearly all the streams of the county in more uniform developments. They include low-lying flood plains and slightly higher terraces, the latter being inundated only at rare intervals. The surface of the first bottoms is in general nearly level, but along the larger streams it may be broken by tributary drainage ways and old channels.

Most of the upland is between 1,060 and 1,100 feet above sea level. Spencer, on a high terrace, lies at an elevation of 1,010 feet above sea level; Langdon, in the hummocky drift region, at 1,066 feet; and Greenville and Cornell, in the level prairie region, at 1,091 and 1,089 feet, respectively.

Practically all the county is drained by the Little Sioux River, which flows into the Missouri River. The drainage of the eastern half of Garfield Township is southeastward, finally reaching the Mississippi through the Des Moines River. The Little Sioux River flows in a channel 50 to 125 feet in width, with an average fall through most of the county of about 3 feet to the mile. Its course is southeastward through a broad terrace plain, which broadens near its confluence with the Ocheyedan, its principal tributary. Here the flood plain of the Little Sioux lies about 75 feet below the general level of the adjacent upland. Beyond the point where it encroaches upon the westward slope of the morainic hills which occupy the eastern part of the county the valley of this stream gradually narrows, being scarcely one-fourth mile wide north of Gillett Grove, and it flows in a channel 125 to 175 feet below the upland 1 to 2 miles inland. The bottom land along the Ocheyedan River averages about 1¼ miles in width. The other principal tributaries of the Little Sioux River flow sluggishly through narrow flood plains.

Elk Creek is bordered by rather strongly rolling slopes, which resemble those along the Little Sioux in the southern part of the county. Its channel lies 100 to 120 feet below the general level of the upland. The slopes to Stony and Willow Creeks are less rolling, and the remainder of the streams are approached by very gentle slopes. Except along the Little Sioux River below Gillett Grove, along Elk Creek in places, and near the mouth of Willow Creek, there are no steep-sided ravines, the slopes leading gradually from broad divides to the valleys. The small intermittent tributaries flowing into these streams in the more rolling region are very short. They have steep slopes and erode actively with each rain. The valleys of practically all the other tributaries entering the Little Sioux from the west pass from V-shaped near their mouths to broadly U-shaped near their sources. Stony Creek has a V-shaped valley along its entire course. Most of the remaining valleys of the county are distinctly U-shaped, and bordered by gently rolling to undulating uplands.

Drainage is best established in the region adjacent to the Little Sioux and Ocheyedan Rivers and the upper reaches of Stony Creek, and along Willow Creek. Over much of the undulating region north and east of the Little Sioux River, except along Elk Creek, there is not sufficient surface relief for adequate drainage. This region was largely in a marshy condition when the county was first settled, and it is now traversed by numerous meandering sloughs. These sloughs are connected by drainage ways that are hardly perceptible in the generally level surface, and they finally empty into a larger stream or into some of the numerous lakes. Some of these lakes are merely marshes or mud flats in the drier seasons. The high prairie region in the southwestern third of the county is apparently poorly drained on the broader divides, but does not contain a great number of marshy sloughs.

Clay County was organized in 1858. After 1856 a number of settlers located on the forested belts along the streams and near the lakes. By 1867, according to the State census, the population had increased to 369, and by 1870 to 1,523. The early settlers came mostly from eastern Iowa, Illinois, Indiana, and Wisconsin. The slow early growth was largely due to Indian troubles, which began in the winter 1856–7 and lasted several years. The State census reports a population of 14,656 in 1915, an increase of about 15 per cent over that of 1910.

According to the 1910 census, 86.5 per cent of the population of Clay County is of native birth. There is no negro population. The principal foreign nationalities represented are German, Swedish, and Danish. There are small settlements of Germans in the vicinity of Everly, of Swedes near Royal, and of Danes in Meadow Township The 1910 census classes all the population outside the town of Spencer, or 76.5 per cent of the total, as rural. This is fairly well distributed over the county, averaging 15 persons to the square mile. The least thickly settled part is the morainic region along the eastern side of the county. The most thickly populated section is in the vicinity of Spencer, Royal, and Greenville. Spencer, the county seat, about 4 miles north of the center of the county, had a population of 4,176 in 1915. Everly, in the western part, has a population of 472; Peterson, in the southwestern corner, 534; and Royal, in the west-central part, 312. Dickens, Webb, Fostoria, Greenville, Langdon, Cornell, Gillett Grove, and Maclay are small trading centers, with facilities for shipping stock and grain. There is a flour mill and a cement-tile factory at Spencer.

Clay County is well supplied with railroads, no point being more than 8 miles from a station. A main line of the Chicago, Milwaukee & St. Paul Railway crosses the county from east to west,

giving an outlet to the eastern part of the State and to Chicago. Branch lines extend south from Spencer to Des Moines, and north to Spirit Lake. A line of the Minneapolis & St. Louis Railway traverses the county from north to south, giving transportation facilities to Minneapolis on the north and to Des Moines and Storm Lake on the south. The Chicago & North Western Railway crosses the southwestern corner of the county, affording communication with the Dakotas on the west and with Chicago to the east. A line of the Chicago, Rock Island & Pacific Railway crosses the southwestern part of the county, giving communication with Minneapolis and eastern markets.

The principal wagon roads are usually kept in good condition, but little attention has been given to the less important highways. All the roads are of earth except the main automobile roads running through Spencer, which are graveled. Practically no point in the county is over 6 miles from a gravel pit. Some of the roads are dragged as soon as possible after rains. All the streams are bridged. Every farming community is reached by mail-delivery routes, and rural telephones are in common use. There are eight consolidated schools in the county. Outside the consolidated districts, schools are maintained at intervals of 2 miles.

The flour mill at Spencer uses more wheat than the county produces. Chicago, Minneapolis, St. Paul, Sioux City, Omaha, and Milwaukee are the most important outside markets. They furnish a steady demand for grain and live stock. Only a small part of the farm products is consumed within the county.

CLIMATE.

The climate of Clay County is essentially the same as that of Palo Alto County on the east, and in the absence of official local data the precipitation and temperature records of the Weather Bureau station at West Bend, in Palo Alto County, are used as a basis for the statements in this chapter.

The mean annual precipitation is 29.62 inches. The total rainfall in the driest year on record (1910) is reported as 13.72 inches, or less than one-half the normal, and for the wettest year (1908) 36.67 inches. Almost two-thirds of the annual rainfall occurs within the growing season, from May to September, inclusive, and the precipitation is usually so well distributed that a drought of more than three or four weeks' duration is rare. May and June are the wettest months of the year, and January and February the driest.

The mean annual temperature is recorded as 45.4° F. January and February are the coldest months, with mean temperatures of

14.7° and 17.5° F., respectively. Snow seldom stays on the ground throughout the entire winter, but often remains for six or eight weeks.

The average date of the last killing frost in the spring is May 4, and that of the first in the fall October 8. This gives an average growing season of 156 days. The latest recorded killing frost in the spring occurred May 17, and the earliest in the fall September 22. The grazing season usually extends from the first of May to the early part of November.

The prevailing wind is from the northwest. The wind is prevailingly from the south or southeast from the middle of May to the middle of September, with occasional hot winds from the southwest in August. Tornadoes are very rare.

The following table, giving the normal monthly, seasonal, and annual temperature and precipitation, is compiled from the records of the Weather Bureau station at West Bend:

Normal monthly, seasonal, and annual temperature and precipitation at West Bend, Palo Alto County.

Month.	Mean temperature.	Precipitation.		
		Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1908).
	°F.	*Inches.*	*Inches.*	*Inches.*
December	21.8	1.23	0.36	0.75
January	14.7	.93	1.25	.47
February	17.5	.89	.10	1.12
Winter	18.0	3.05	1.71	2.34
March	30.8	1.67	.14	1.62
April	47.2	2.84	.35	2.51
May	59.2	4.00	1.59	6.63
Spring	45.7	8.51	2.08	10.76
June	68.2	4.17	3.25	9.28
July	73.0	3.56	1.32	3.00
August	70.2	3.89	2.61	6.04
Summer	70.5	11.62	7.18	18.32
September	61.6	3.07	1.68	.57
October	48.1	1.93	.88	3.27
November	32.5	1.44	.19	1.41
Fall	47.4	6.44	2.75	5.25
Year	45.4	29.62	13.72	36.67

AGRICULTURE.

Originally almost the entire area of Clay County, except forested strips around the lakes and along the Little Sioux River south of Spencer, supported an abundance of prairie and slough grass. Considerable slough grass still remains along the creeks and intermittent drainage ways. The narrow forested strips were first settled, owing largely to the wood and water supply. At first it was supposed that spring wheat, rye, barley, and oats were the only crops that could be grown readily, and these grains, with some corn and potatoes to supply home demands, were the first crops grown. Agriculture did not make much progress until the late sixties, when the Indians were subdued and settlers began to arrive in large numbers.

Until this time spring wheat had been the leading money crop, but with decreasing yields as a result of continuous cropping and with growing realization of the possibility of good corn yields the growing of corn was greatly stimulated, and by 1900 the area in this crop was more than four times that in wheat, although the latter had increased from 6,029 acres in 1880 to 19,302 acres in 1900.

Corn has been the crop of first importance since the early seventies. Much of the first seed corn, brought from eastern Iowa, was found to mature too late, and better adapted varieties were gradually introduced. The building of railroads in the late seventies and early eighties stimulated agricultural development, especially the production of corn. As the yields of corn decreased after several years of continuous cropping the more progressive farmers began to grow small grains, legumes, and corn in rotation, and with the keeping of more live stock and the application of barnyard manure the productiveness of the soils has been maintained. Oats have been the crop of second importance since the early seventies. The early settlers used oats to supplement hay in the feeding of stock, and it was not until 1895–1900 that even a small proportion of the crop was placed on the market. A considerable acreage of newly broken prairie land was devoted to flax between the years 1890 and 1900, but as yields decreased when the crop was grown on the same land more than two years in succession this crop became relatively unimportant after 1900. Rye and barley have been grown since the beginning of the agricultural development of the county, but rye has never been produced on a commercial scale. Barley has been grown more extensively than wheat since 1890, though the acreage has declined greatly.

The agriculture of Clay County at the present time consists of the production of general farm crops for sale and for farm use, combined with hog raising. Beef-cattle production and feeding, as well

as dairying, are increasing in importance. The type of farming is remarkably uniform over the whole county. The principal crops grown are corn, oats, and hay, and the secondary crops, barley, wheat, flax, potatoes, and buckwheat.

Corn is the principal money crop of the county. The area devoted to this crop increased steadily from 21,795 acres in 1879 to 88,261 acres in 1899, but in 1909 the crop occupied only 82,035 acres. The State census of 1915 reports 104,456 acres, or nearly one-third the total area of the county, in corn, with a production of 4,424,361 bushels, an average of 42.3 bushels per acre. Most of the corn is from home-grown seed, and probably 35 per cent is of the Silver King variety. This is recommended for this section of the State by the Iowa Agricultural Experiment Substations, and it seems to be the earliest and most prolific variety. The remainder of the crop is mostly of mixed yellow varieties. Between 50 and 65 per cent of the corn produced in the county is used for feeding work stock, fattening hogs and cattle, and feeding dairy stock. The remainder is sold to local elevators and shipped, mostly to Chicago and Omaha. In the vicinity of Everly, where considerable feeding is done, not enough corn is produced for local consumption.

Oats have shown an increase in acreage at each census period. The crop was grown on 6,195 acres in 1879 and on 71,356 acres in 1909. The State census reports 79,593 acres in oats in 1914, with a production of 2,835,134 bushels, or an average of 35.6 bushels per acre. Approximately 22 per cent of the improved farm land of the county is in oats, and the crop ranks second in importance. About one-half the acreage in oats is devoted to early varieties. Most of the seed oats are mixed. Of the pure strains grown the Early Champion, Green Russian, and Kherson probably lead, in the order named. A comparatively new strain of white oats, the Iowa 103, has given higher yields and proved more prolific in experiments throughout the county, and it is rapidly becoming the popular variety. About one-half the oat crop is fed to work stock, calves, and small pigs. The remainder is sold to local elevators and shipped, mainly to Chicago.

The third most important crop is hay. In 1909 hay was cut from 56,547 acres, with a production of 80,118 tons. Of the total area, 32,445 acres were in tame or cultivated grasses, which yielded about 1.5 tons per acre, and 24,102 acres were in wild, or prairie, grasses, which gave an average yield of about 1.3 tons per acre. Most of the wild hay is cut from the bottom-land soils, and the acreage is gradually decreasing as the land is drained and devoted to cultivated crops. Practically all the hay produced, both tame and wild, is used on the farm for feeding work stock and beef and dairy cattle. In some parts of the county not enough hay is grown for home consumption, and a considerable quantity is shipped in.

Clover and timothy mixed constitute the most important tame-hay crop. The census of 1910 reports 18,044 acres in this combination, yielding 1½ tons to the acre. Timothy seeded alone ranks next, occupying 12,569 acres and giving an average yield of 1.3 tons per acre. Practically all the clover grown alone for hay is red clover. This is reported on 419 acres, with an average yield of 1.7 tons per acre. Usually in seeding pastures some alsike clover is sowed with bluegrass and timothy. The 1910 census reports 132 acres in millet and 1,258 acres devoted to other tame grasses.

Alfalfa has been tried by several farmers in the last few years, and its success on the better drained soils of the county indicates that it can be made a profitable crop. The census of 1910 reports only 23 acres in alfalfa, but the State census reports 248 acres for 1914, and the acreage has been increasing quite rapidly since that year. Conservative estimates are that about 2,000 acres have been seeded to alfalfa in the last two years. Alfalfa affords three or four cuttings a year and gives higher average yields than either clover or mixed clover and timothy.

Barley has been relatively unimportant since 1905. The area devoted to this crop increased from 1,837 acres in 1879 to 14,218 acres in 1889 and 24,483 acres in 1899, but in 1909 the crop occupied only 1,648 acres. The State census reports 2,440 acres in barley in 1914, with an average yield of 28.8 bushels to the acre. The crop is used as a substitute for other small grains in rotations and as a money crop. Only the 6-rowed varieties are grown. Some of the barley produced is fed to growing pigs, but the bulk of the crop is sold to local elevators and shipped to outside markets, principally Milwaukee.

Wheat was an important crop until about 1905. Its acreage decreased from 19,302 acres in 1899 to 542 acres in 1909. Until recent years practically all the wheat grown in Clay County was of the spring varieties, but of late many farmers have been obtaining good results with winter wheat, and it is being grown on a larger acreage each year. Wheat occupied 2,035 acres in 1914, and yielded an average of 21.6 bushels to the acre. Winter varieties occupied about one-third of the total acreage in 1914, and, according to the census, gave an average yield of about 4 bushels per acre higher than spring wheat. The leading variety of winter wheat is the Turkey Red. Bluestem and Marquis are the most popular spring varieties. Wheat very seldom winterkills. Its small acreage is due to the fact that other crops are considered more profitable. The wheat produced is all used by local flour mills.

Potatoes in 1914 occupied 702 acres, and produced 70,094 bushels. Nearly every farmer grows enough potatoes to supply home needs, and has a small surplus for sale in favorable seasons, but practically

no potatoes are shipped from the county. Market gardening is carried on inextensively in the vicinity of Spencer.

The apple is the only fruit of importance, and this is practically nowhere grown on a commercial scale. Summer and fall varieties, principally the Wealthy and Duchess, constitute the bulk of the crop, but there are many trees of the Northern Greening, a winter apple, at present apparently the most popular variety. The census of 1910 reports 24,172 apple trees in the county. There is a small production of cherries, plums, peaches, grapes, strawberries, blackberries, and raspberries. In general, little care is taken of the fruit trees and many of the farm orchards are dying out. Not enough fruit is produced in the county to supply the home demand.

Hog raising is the most important live-stock industry. The pure-bred herds consist mainly of Poland-China or Duroc-Jersey stock, which are of about equal importance. There are also a large number of Chester Whites. Most of the hogs, however, are of mixed breeds, and little attention is directed toward keeping the strains pure. The State census reports the number of hogs raised in Clay County in 1914 as 63,827, or an average of about 39 to the farm. After the local demand is supplied, most of the hogs sold are either shipped directly to the large markets or sold to local buyers. The markets at Chicago, Omaha, and Sioux City get most of the hogs shipped from the county.

Dairying, in combination with general farming, is gradually being extended. The State census of 1915 reports 10,835 milch cows in the county, and the number is increasing annually. The revenue derived from all dairy products in 1914 was $304,879. Ordinarily the farmers who have dairy products to sell keep about 8 cows. There are about 10 farmers in the county milking 20 or more cows the year round. As a rule, dairying is carried on throughout the year. The cows are kept on pasture during the growing season, with some supplementary feed. There are only about 60 silos in the county, but the number is steadily increasing. In the past little thought has been given to the selection of dairy stock, and most of the animals are grade Shorthorns. The number of Holstein cows is increasing rapidly, and there are a few Holstein herds scattered over the county. Most of the milk is separated on the farm, the cream being sold to local creameries. Most of the butter is shipped to New York and Boston; the remainder is sold locally.

Probably over 75 per cent of the beef cattle raised in the county are of mixed breeds, but more pure-bred stock is being raised than in the past. The Shorthorn, Hereford, and Angus breeds, in the order named, lead in popularity. Most of the beef cattle fed are raised locally, but several carload lots of western cattle are annually

shipped in and fattened during the fall and winter months, principally in the vicinity of Everly. The beef cattle raised in the county are kept largely on pasture, with the addition of roughage in some cases. They are finished on roughage and concentrates. There were nearly 35,000 beef cattle in the county in 1914, of which nearly 14,000 were calves under 1 year of age. Nearly all the beef cattle are sold directly from the farm to the large markets, chiefly Chicago.

The State census reports 13,942 horses in Clay County in 1914, of which 1,300 were colts under 1 year of age. There is an average of about 8 horses to the farm. Many farmers raise one or more colts to supply work stock, and frequently have a few animals to sell. Considerable attention has been paid to the breeding of draft horses, of which the Percheron is the favorite breed, followed closely by the Belgian Draft and Clydesdale.

The raising and feeding of sheep is a source of considerable revenue. The State census reports 3,020 sheep in the county in 1914. Several carload lots of western sheep are fattened annually, principally by farmers in the vicinity of Everly, Greenville, and Spencer. Most of the sheep raised in the county are kept on farms along the streams.

Most of the bottom lands throughout the county are poorly drained or subject to overflow and have been kept in pasture or meadow grasses. The steeply rolling land along the lower course of the Little Sioux River and along Elk Creek, where cultivation is difficult, is also used mainly as pasture. Most of the cattle and sheep feeding is carried on in these sections of the county. The agricultural methods are practically uniform on all the types of soil over the remainder of the county. The adaptation of certain crops to particular soils is recognized to a considerable extent. The farmers realize that the Lamoure loam and silty clay loam, where well drained, are excellent corn soils, but that small grains on these soils are inclined to produce too much straw at the expense of grain. All the first-bottom soils are considered better for hay and pasture grasses than the upland types, although the greater part of the Wabash loam gives good yields of oats, corn, wheat, and barley. The heavier upland soils, unless very well drained, are considered rather poor for corn in wet years, and the O'Neill loam, O'Neill fine sandy loam, and Shelby fine sandy loam are comparatively undesirable for corn in dry years. The well-drained, lighter upland types are considered best for alfalfa.

Definite systems of crop rotation are practiced by the more progressive farmers. Practically all the farmers realize the need of rotating crops, owing mainly to the decrease in corn yields brought about through continuous cropping. The rotation most commonly followed consists of corn 2 years, oats 1 year, and clover and tim-

othy 2 years. Some farmers using this rotation plant corn only 1 year. In some cases corn is grown continuously on the same land for 5 or 6 years, especially on the newly broken bottom lands. Usually, however, some other crop is grown after the second year.

Practically all the corn grown is checkrowed, but some is drilled for use as ensilage or fodder. Corn is usually cultivated four or five times. Much of the crop is "hogged down," and probably 7 or 8 per cent is fed to stock in the field. Cornstalks are pastured after the grain is removed. The following spring the ground is plowed 5 or 6 inches deep, harrowed several times, and seeded to a small grain, with which some hay crop, usually clover and timothy mixed, is sowed. Plowing is done with 5-horse teams on the heavier soil and with 4-horse teams on the lighter types. Following the harvesting of the small grain, the clover and timothy afford one cutting of hay. The later growth is usually allowed to seed, to make pasture the following year. There may be some pasturage the first year if the season is favorable. The land, if pastured, is plowed early the following spring and returned to corn. Many farmers report that corn usually yields about 5 bushels per acre more the first year following clover than the second year.

Oats, wheat, and barley are seldom grown two years in succession, as the yield usually is greatly reduced the second season. The seed is usually sown broadcast and harrowed in, but some farmers use the drill. Winter wheat usually follows spring wheat or oats. Alfalfa has not been grown long enough to permit certain methods of handling to become common, but the best success so far has followed early spring or early August seeding in a firm seed bed.

In general, the most improved farm machinery is used in Clay County, and the implements are usually well cared for when not in use. The equipment consists of gang plows, sulky plows, disk harrows, spike-tooth harrows, corn planters, 2-horse and 4-horse cultivators, corn binders, grain binders, grain drills, hay loaders, mowing machines, hayrakes, hay stackers, outside grain elevators, and manure spreaders. Hay forks and tracks are used to put hay under roof. Corn-shelling and grain-thrashing outfits travel from farm to farm in season. Most of the farms are equipped with commodious barns, arranged for the storage of hay and grain and the sheltering of work stock and cattle, and have well-lighted hog houses and chicken houses, and supplementary buildings. In favorable seasons the fields and farmsteads are kept comparatively free from weeds. Most of the farms are fenced with barbed wire, and the use of woven wire is rapidly increasing.

Practically no commercial fertilizers are used in Clay County at present, although $1,200 was spent for fertilizers in 1909. Liming

the soils has not always proved beneficial, but it is necessary in certain cases where the soils have become acid. The value of plowing under a green-manure crop is recognized by most farmers and is practiced to some extent. When grown primarily for soil improvement, red clover is sowed alone. When a crop is turned under in the rotation it is the second year's growth of clover. Ordinarily the supply of barnyard manure is not sufficient to supply the entire farm, and only the poorer spots receive liberal applications. Manure is usually applied to clover land that goes into corn the following year. Pastures and hay lands are not ordinarily top-dressed.

Efficient labor is rather scarce during the grain-harvesting and corn-husking seasons, when most needed, but usually enough labor is obtainable to do the ordinary farm work. Nearly all the laborers are of American birth. Most of the help is hired for nine months or by the year, in the former case receiving $30 to $35 a month and in the latter case $25 to $30 a month, board and washing being given in addition. During the harvesting season laborers are usually paid $2.50 a day, and for corn husking 4 or 5 cents a bushel. Many farmers hire families, in order to obtain more reliable help, supplying usually a small house and giving the privilege of keeping some stock for private use. Most of the farm work, however, is done by the farmers and their families. In 1909, 737 farms, or 44.2 per cent of the total number in the county, used hired labor, at an average expense of $232 each.

The State census of 1915 reports 1,651 farms in Clay County, of an average size of about 203 acres. The average size has changed little since 1889. Farms range in size from 40 to 80 acres near the towns to over 1,000 acres farther away. The majority comprise between 160 and 240 acres.

Many owners have moved to the towns in recent years, and the percentage of farms operated by owners has decreased from 77.8 per cent in 1879 to 45.2 per cent in 1909. In 1914, 558 farmers were operating only land owned, 238 were operating land owned and land leased, 338 were operating farms leased for cash, 121 farms leased for a share of the crop, and 336 farms leased in part for cash and in part for a share of the crop. Land rented on a cash basis brings $5 to $7 an acre. On the share basis the owner receives two-fifths of the grain, delivered at the market. Cash rent is usually paid for pasture and hay land.

According to the census, 93.1 per cent of the area of the county was in farms in 1910, and 93.3 per cent of the land in farms was improved. Land values vary according to the soil, topography, improvements, location, and distance from market. In the southwestern third of the county unimproved land is held at $125 to $150 an acre, and improved land at $150 to $225 an acre. Over the remainder

of the county land values are quite variable, ranging from $100 to $125 an acre for unimproved land to $125, $175, or even $200 an acre for improved land. The average selling price of farm land for the county is about $150 an acre.

SOILS.

On the basis of topographic position the soils of Clay County may be classed in three general groups—viz, upland soils, high-terrace soils, and first-bottom soils. The various types, or textural soil units, are grouped into series on the basis of similarity in color, origin, topography, and structure. The upland includes soil material of more varied texture than either the high terraces, which are predominantly sandy, or the first bottoms, which are heavier textured.

The soils of Clay County are not related to the underlying rocks, but are derived from the bowlder clay of the unmodified glacial drift. This drift is an unstratified mass of material brought from the north by the ice sheet which at one time covered the northern half of the continent. It consists chiefly of clay, with varying proportions of silt, sand, gravel, and bowlders. Most of the gravel and bowlders are quartzite, granite, and gneiss, but there is some limestone. This surface mantle of bowlder clay, which is classed as Wisconsin drift, ranges in thickness from a few inches to 150 feet or more.[1] It is underlain by the "blue clay" of the Kansan drift. Frequently a layer of sand and gravel occurs between the two. This blue-clay layer is reported by well diggers as averaging between 30 and 60 feet in thickness. It is usually underlain by the so-called pre-Kansan sands. In some places it rests on sandstone. These lower sandy layers are the permanent sources of water supply throughout the county.

Since deposition the surface mantle has been modified by the leaching out of much of the lime from the surface 3 feet and by the incorporation of organic matter. Except for an occasional pebble or bowlder the surface soil is comparatively free from rock fragments. In shallow depressions where water originally collected more or less fine material has washed in from the adjacent slopes, resulting in the filling up of the depressions with a heavy soil or in the accumulation of the remains of plants to form peat. On the slopes where erosion has been active the clay particles have been washed away, leaving a lighter textured soil.

Small, scattered knolls and ridges of sand, bowlders, and gravel mixed with clay and silt occur in the eastern part of the county. These were probably formed by the strong current of subglacial

[1] Annual Report of the Iowa Geological Survey, Vol. XI, Geology of Clay and O'Brien Counties, by Macbride.

rivers and streams, which deposited only the coarser material held in suspension. Owing to the open, coarse structure of most of this soil plant life has not been abundant, and the surface soil is not as high in organic matter as is the case in the remainder of the upland types.

The terrace or second-bottom soils occur on nearly level, bench-like areas lying 10 to 15 feet above the first bottoms along the larger streams. They are also developed near lakes. These soils are practically free from overflow. Most of the second bottoms consist of an assorted mass of coarse sand and gravel, with a covering of loess-like material, possibly alluvial or wind-blown in origin. The average thickness of the substratum is reported as 25 to 30 feet. It rests on saturated blue clay. Where the loesslike surface covering is less than 3 feet deep the soil is classed in the O'Neill series. Where it is 3 feet or more deep the soil is included in the Waukesha series. Only a small percentage of the terrace has a layer over 3 feet in thickness. The terrace soils that have highly calcareous, heavy subsoils and are poorly drained are classed in the Fargo series.

Since reaching their present level most of the streams have deposited on their flood plains material washed from the higher lying glacial-drift soils. These first-bottom soils are predominantly heavy, having been deposited in most areas by sluggish streams of low gradient. In some places they have been formed by the collection of material in small depressions or sloughs which remain marshy the greater part of the year and have only recently cut outlets deep enough for the removal of the surface water. Practically all the first-bottom alluvium is high in organic matter. With the exception of a comparatively small development of Muck and Peat, the first bottom soils are correlated in the Wabash and Lamoure series.

The upland soils are separated into three series—the Carrington, the Webster, and the Shelby, based upon differences which are due mainly to the character of the original glacial material.

The surface soils of the Carrington series are essentially dark brown or nearly black, and rather shallow. The subsoils are light brown to yellowish brown, and usually somewhat heavier than the surface soils. Both soil and subsoil may contain a small proportion of glacial gravel and bowlders. The series is only moderately calcareous, neither soil nor subsoil having sufficient lime to effervesce with acid.

The soils of the Webster series are black and the subsoils gray or mottled gray and brown. The subsoils are heavy in texture, ranging from silty clay loam to clay, and calcareous, usually effervescing with acid. Occasional glacial bowlders are scattered over the surface or embedded in the soil. The series has been formed through the weathering of glacial till under conditions of poor

drainage. The series occurs on nearly level or undulating till plains where erosion has not set in, or in areas of restricted drainage where shallow lake or swamp conditions formerly prevailed.

The soil profiles in this series are similar in color and texture to those in the Fargo series. This series, however, has a topographic position on the upland instead of in lake basins and depressions, and is derived from till in position instead of from reworked glacial drift. It differs from the Carrington in the deep black color of the soil and the gray or mottled color and the high lime content of the subsoil.

The Shelby series includes types with drak-brown to almost black soils and light-brown or yellowish-brown, heavier upper subsoil, with a lower subsoil of yellowish-brown, sandy and gravelly clay. In places there is a substratum of loose sand and gravel. These soils are derived from the coarser drift, usually where it is exposed on slopes. The topography varies from gently rolling to rough.

The surface soils of the types included in the Waukesha series are dark brown to black. The subsoils are light brown or yellowish brown and heavier in texture. Neither soil nor subsoil is highly calcareous. The series occupies terraces above overflow, and has good drainage.

The O'Neill series, which differs from the Waukesha in having the gravel substratum within 3 feet of the surface, is inclined to be somewhat droughty. The surface soils are dark brown to nearly black, resting on light-brown to brown upper subsoils. The O'Neill soils differ from the Wabash in their occurrence on terraces above overflow, as well as in the presence of the bed of gravel in the subsoil.

The Fargo series has dark-brown to black surface soils and brown or mottled drab and yellow subsoils. These soils occur on lake and river terraces where glacial till has weathered under poor drainage conditions.

The Wabash series is characterized by dark-brown to black surface soils and gray or brownish-gray subsoils. The surface soils are high in organic matter. Drainage in most places is rather poor.

The Lamoure series includes types having very dark brown to black surface soils overlying drab to brownish or yellowish-drab subsoils. It differs from the Wabash mainly in having a high lime content in both surface soil and subsoil.

Soil made up largely of the organic remains of water-loving plants and grasses accumulated in old lakelike depressions and sloughs is mapped as Muck and Peat.

Fourteen types of soil, including Muck and Peat, are mapped in Clay County. Their description in detail and their relation to agri-

culture are brought out in the following pages of this report. The table below gives the name and the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Carrington loam	102,272	31.3	Wabash loam	4,032	1.1
Steep phase	10,496		Muck and Peat	3,520	1.0
Webster silty clay loam	72,768	20.2	Fargo silty clay loam	2,112	.6
Carrington silt loam	54,144	15.0	O'Neill fine sandy loam	2,048	.6
Lamoure silty clay loam	42,944	11.9	Lamoure loam	1,024	.3
O'Neill loam	29,184	8.1	Waukesha silt loam	512	.1
Carrington fine sandy loam	20,416	5.7			
Wabash silt loam	10,688	2.9	Total	360,320	
Shelby fine sandy loam	4,160	1.2			

CARRINGTON FINE SANDY LOAM.

The surface soil of the Carrington fine sandy loam, extending to a depth of 8 or 10 inches, is a dark-brown to dark grayish brown fine sandy loam. This is underlain by a grayish-brown, rather compact fine sandy loam to light loam, grading at about 24 inches into a brown to light-brown or yellowish-brown fine sand which has a small content of clay. Where the soil has been under cultivation for only a few years, or where it has been kept in good condition, the organic content is moderately high, though not as high as in the heavier members of this series. In some places much of the organic matter has been allowed to leach away, and the surface soil is dark grayish brown when wet and grayish brown when dry. Occasionally on the breaks to streams some coarser material, consisting of coarse sand and glacial pebbles, occurs throughout the soil section. Glacial bowlders occur in the soil or on the surface in places. Locally the texture of the surface soil may vary from a light loam to a sandy loam.

This type is of glacial origin. The uniformity of the material would indicate that it had been reworked by water and possibly wind, but it may be the result of feeble glaciation. Like the other prairie soils, the type was originally covered with grass, without much tree growth.

The Carrington fine sandy loam is practically confined to the section north and east of the Ocheyedan and Little Sioux Rivers. It occurs in scattered areas mainly on low ridges and small hills and in gently rolling situations, but to some extent on slopes to streams. None of the areas cover more than 4 square miles. The type is well drained, and on some of the steeper slopes to streams it is subject to rather severe erosion. The internal drainage is rather rapid, but

in most places the subsoil is compact enough to retain moisture fairly well. In years of moderate and well-distributed rainfall this soil is usually as productive as the Carrington loam, but prolonged dry spells during the growing season are likely to reduce yields.

Probably 80 per cent of this soil is cultivated, the remainder being in native grass and used for pasturage. The same crops are grown as on the Carrington loam. Clover and timothy are probably grown more extensively in relation to corn than on the heavier soil. Corn ordinarily yields 25 to 35 bushels per acre,[1] oats 25 to 35 bushels, barley 18 to 25 bushels, and spring wheat 14 to 18 bushels. Clover and timothy yield 1¼ to 1½ tons of hay per acre, red clover alone 1¼ to 2 tons, timothy about 1 ton, and alfalfa 2 to 3 tons. There is some difficulty in getting a stand of alfalfa, but when this crop is established it gives good yields. The live-stock industries are practically the same as on the Carrington loam, but more stock is pastured.

On account of its light texture and good drainage, this is an early and easily managed soil. It can be tilled under a wide range of moisture conditions without danger of baking or forming clods. It is handled in much the same way as the Carrington loam. The selling value of the land ranges ordinarily from $100 to $150 an acre.

The farm practices and methods of soil treatment that tend to increase the productiveness of the Carrington loam are equally beneficial to this type. There is a greater need for the incorporation of organic matter. The steeper slopes should be kept in the original prairie grass or seeded to a good cover crop, to prevent erosion and leaching.

CARRINGTON LOAM.

The surface soil of the Carrington loam, extending to a depth of 8 or 10 inches, is a dark grayish brown to dark-brown, mellow loam, moderately high in organic matter. It is underlain by a light-brown to yellowish-brown, rather compact, heavy loam to light silty clay loam or sandy silt loam. At about 30 inches the underlying bowlder clay is usually encountered. To a depth of 36 inches this consists of a yellowish-brown, rather loose sandy loam or sandy clay. The lower subsoil often contains small lime concretions and some glacial pebbles. There is a relatively high percentage of fine sand throughout the 3-foot section. The subsoil contains numerous reddish-brown iron stains.

The soil is quite variable within certain limits. In places the surface soil is a heavy loam and the light-brown, compact, heavy loam subsoil continues to a depth of 3 feet. This is the case es-

[1] Statements in this report as to crop yields are based on information obtained from farmers.

pecially in the flatter areas and on the very gradual slopes to the areas of Lamoure silty clay loam. A good example of this variation occurs on the higher divides north of Everly, where the soil greatly resembles the Webster silty clay loam. In some of the more rolling areas glacial pebbles and bowlders occur on the surface and throughout the 3-foot section, but rarely in quantities large enough to interfere with cultivation. They are derived chiefly from quartzite, granite, and gneiss, and are in places covered with a coating of lime. In a few small included areas in the morainic region in the northeastern corner of the county gravel and sand, practically free from clay, underlie the soil at 24 to 27 inches. Small knolls occupied by the light-colored Shelby fine sandy loam, likewise too small to map, are occasionally included in the eastern and northeastern parts of the county. In general, the shallower and lighter textured surface soil and the looser subsoil are developed on the narrow crests and rather steep slopes, and the heavier surface soil and more compact subsoil in the flatter areas and on the gentler slopes.

The Carrington loam is one of the most extensive soils mapped. It covers most of the prairie region in the eastern and northern three-fourths of the county, including the territory north and east of the Ocheyedan and Little Sioux Rivers. A narrow strip occurs on the gentle south and west slopes to the river, from the mouth of Lexington Creek west to the county line. Elsewhere the surface varies from undulating to gently rolling, with long and gentle slopes. The stream valleys usually are broadly U-shaped, but in the vicinity of the rivers they may become V-shaped, with smooth sides. Surface drainage is almost everywhere thorough, but artificial drainage is beneficial in a few of the lower-lying areas. The subsoil as a rule retains water well, but is less retentive than that of the heavier members of this series.

Like the Carrington silt loam and Webster silty clay loam, this soil originally supported a growth of prairie grass, with very little timber. Some scrub oak originally grew on the lake shores and on the slopes to the Little Sioux River just north of Gillett Grove. In elevation above sea level the type probably varies more than any other important soil in the county. Its average elevation is undoubtedly less than that of the Webster silty clay loam.

About 85 per cent of this soil is under cultivation, only the rolling areas adjacent to the first bottoms being used for pasturage. All the common crops are grown. Corn is the principal money crop, with oats second in importance. Probably a larger percentage of the corn and oats produced is fed on the farm than is the case on the Webster silty clay loam. The acreage devoted to cultivated grasses is relatively greater. In relation to other crops, more alfalfa and winter wheat are grown on this soil than on any other type in the county.

Alfalfa has given very good results, with proper management, and its acreage is increasing annually. Hog raising and the raising and feeding of beef cattle are the principal live-stock industries. Dairying is carried on to some extent in the vicinity of the towns. More beef cattle are raised than on the Webster silty clay loam, owing chiefly to the larger number of grass-covered sloughs on the near-by Lamoure silty clay loam, which have not been drained or put under cultivation and which furnish excellent summer pasturage. Considerable pure-bred stock is raised on this soil in the vicinity of Everly, Spencer, and Webb. Cattle and sheep are fed quite extensively north of Everly. As on practically all the other soils of the county, fruit growing has been neglected, but probably the only commercial orchard in the county is on this soil, near the center of Logan Township.

Yields on this soil vary somewhat with the position on slopes or flat divides, and with the content of sand. Ordinary yields are about as follows: Corn 30 to 35 bushels per acre, oats 32 to 37 bushels, barley 20 to 25 bushels, spring wheat 15 to 20 bushels, and winter wheat 17 to 25 bushels per acre. Of the cultivated grasses, clover and timothy mixed are most extensively grown, with average yields of 1¾ to 2 tons of hay per acre. Red clover alone usually yields 1½ to 2 tons, timothy 1 to 1½ tons, and alfalfa 2½ to 3½ tons per season. Potatoes ordinarily yield 85 to 100 bushels per acre.

This soil is easily cultivated and maintained in good tilth throughout the year. Heavy farm implements are used, but much less draft power is required than on the heavier members of the Carrington series. The surface water usually flows off readily without serious erosion, and the rather compact subsoil retains water well. The soil warms up quickly in the spring, except near poorly drained areas of other types, and can be cultivated and seeded early.

The value of crop rotations is generally recognized, and definite systems covering 4 or 5 years have been adopted by some farmers. The rotations are much the same as those on the Webster silty clay loam, except where alfalfa is used in the place of clover. This makes a longer rotation, covering usually about 8 years, the alfalfa being left 4 or 5 years. Barnyard manure is applied once in 6 or 8 years.

Farms on the Carrington loam range in price from $125 to $175 an acre, depending upon the condition of the soil, the location with reference to markets, and the improvements. The best improved farms are in the vicinity of the towns.

Greater attention to the rotation of crops and to the incorporation of organic matter, either by keeping more live stock or by plowing under green-manure crops, are needed on this soil. The addition of organic matter has proved beneficial both in improving the tilth and in increasing the capacity of the soil to hold moisture. Little of the

land is subject to severe erosion, but the use of a cover crop on some of the steeper slopes would prove beneficial in preventing washing and leaching.

Carrington loam, steep phase.—The steep phase of the Carrington loam includes areas in which the surface is too steeply rolling to permit of ordinary farming. The surface soil is quite variable, ranging from a very sandy loam in some places to almost a clay loam in others. On some of the steepest slopes the surface soil has been completely eroded away. In general the phase consists of a dark-brown loam, 8 inches deep, underlain by typical bowlder clay, which is usually a buff or pale-yellowish silty clay loam to silty clay. Both soil and subsoil carry varying amounts of glacial pebbles and bowlders. In places bowlders 2 or 3 feet in diameter occur on the surface.

This phase is practically confined to the southern half of the county, where it occurs in narrow, irregular strips on the slopes to the Little Sioux River and its short tributaries. A narrow strip occurs on each side of Elk and Willow Creeks for a short distance. From the lower to the higher margin of the strips there is a range in elevation of 50 to 200 feet. Along the southern border of the county the slopes occupied by this soil are almost precipitous. Erosion is very active, new gulleys often being formed with each heavy rain.

This phase is not important, only an occasional small field on some of the more gradual footslopes being under cultivation. Where large enough to map separately these cultivable areas are classed with the typical Carrington loam. Most of the steep phase supports a good growth of the native prairie grasses, with some trees. Nearly all the forest existing in the county when first settled was on this type. It consisted chiefly of basswood, prickly and white ash, soft maple, box elder, white elm, and cottonwood, with shrubby growths of smooth sumac, wild plum, hazelnut, choke cherry, crab apple, and red haw. The land is used almost entirely for pasture. It is usually owned in conjunction with the surrounding tillable soils.

CARRINGTON SILT LOAM.

The surface soil of the Carrington silt loam is a dark-brown, moderately heavy silt loam. The subsoil, beginning at about 12 inches, consists of a dark yellowish brown, compact, heavy silt loam, grading at about 22 inches into a brownish-yellow to yellowish-brown, less compact, light silty clay loam. Over much of the type the intermediate layer is lacking, and the subsoil is a yellowish-brown to brownish-yellow, rather friable, light silty clay loam. The lower subsoil in many places effervesces with hydrochloric acid. Some faint

reddish-brown iron stains appear in places. The surface soil is quite high in organic matter, though not as high as that of the Webster silty clay loam. The two soils have been formed in much the same manner and the boundaries between them are very indefinite in many places, owing to the small difference in clay content. Occasional glacial pebbles or bowlders occur in the Carrington silt loam, but rarely on the surface. The type is quite uniform over its entire area, but the soil may be somewhat thin on some of the more abrupt slopes, where it becomes grayish brown when dry.

The Carrington silt loam is the third most extensive upland soil. It is best developed in the better drained areas of the high upland south and west of the Ocheyedan and Little Sioux Rivers. The largest bodies occur east and northeast of Greenville, along Willow Creek, and on the high prairie northeast of Gillett Grove. Smaller areas are scattered over the rest of the county. In general the surface is undulating to gently rolling. It is more strongly rolling in the areas adjacent to the lower course of Willow Creek. Usually the surface in this part of the county grades from sloping on the associated Carrington loam to gently undulating on the silt loam, and then to nearly flat on the Webster silty clay loam. In the southern part of the county the Carrington silt loam lies gently sloping between the steep phase of the Carrington loam on the one side and the flatlike areas of the Webster silty clay loam on the other. Broad U-shaped valleys are characteristic over practically the entire type. Drainage in most places is good, but the type is rather slowly drained in some of the flatter areas adjacent to the Webster silty clay loam. Tile drainage has proved beneficial here.

The Carrington silt loam forms part of the prairie region of the county along with the associated loam and Webster silty clay loam. It originally supported a luxuriant growth of prairie grass, with little or no timber. The soil is practically all in cultivation, and it ranks as an important agricultural soil. The same crops are grown as on the Webster silty clay loam, namely, corn, oats, and hay, with considerable barley and some wheat. A somewhat larger relative area is devoted to alfalfa. The same live-stock industries are carried on, but more beef cattle are raised and fattened, owing to the proximity of this soil to the stream-bottom soils and to the steep phase of the Carrington loam, where the land is used mostly as pastures.

Corn on the Carrington silt loam ordinarily yields between 30 and 40 bushels per acre. Other crops yield about the same as on the deep phase of the Webster silty clay loam. The soil is handled and manured in practically the same way as the associated heavier type, except that less draft power is required, as the soil is more friable, and less sticky when wet.

This land ordinarily sells for $150 to $175 an acre, the price depending upon the location and improvements. The farms as a rule are well improved and well kept.

The best farmers on this soil apply large quantities of barnyard manure annually where erosion has been active. In case enough manure is not available to treat the entire phase the plowing under of a green-manure crop, like red clover, would prove beneficial. The growing of cover crops to prevent further washing would also be good practice.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the Carrington silt loam:

Mechanical analyses of Carrington silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331450	Soil	0.1	1.0	0.7	5.0	7.4	59.2	26.9
331451	Subsoil	.3	2.8	2.4	6.7	8.4	53.3	26.2

WEBSTER SILTY CLAY LOAM.

The surface soil of the Webster silty clay loam is a very dark brown or nearly black, moderately heavy silty clay loam, about 15 inches deep. This is underlain by a dark yellowish brown, rather compact, crumbly silty clay loam. At about 24 inches the subsoil becomes a brownish-yellow, crumbly silty clay loam. Both layers of the subsoil often have a grayish cast, especially in the more nearly level areas. Numerous reddish-brown iron stains occur in the lower part of the 3-foot section, and occasionally in the intermediate layer. The surface soil and the upper subsoil rarely contain enough lime to effervesce with hydrochloric acid, but the lower subsoil often does. The surface soil is quite high in organic matter.

This soil has undergone very little modification from its original condition as glacial till, except by the addition of organic matter. Glacial bowlders and pebbles occasionally occur on the surface or through the soil section, but they are in no place numerous. The surface soil is quite uniform in depth over the entire area of the type. When properly cultivated it seldom forms clods or becomes refractory, and it does not bake or crack badly upon drying. The boundaries drawn between this soil and the Carrington silt loam or loam are necessarily rather arbitrary in places, owing to the gradual change in texture. The soil originally supported a growth of slough and prairie grasses, with practically no timber.

Most of this type occurs in a large continuous area in the southwestern third of the county, interrupted only by a narrow strip

of other types along Willow Creek. It extends from Greenville west and south to the county lines. A few small areas occur scattered over the remainder of the county, mainly in the large body of Carrington loam. Here it usually occupies the broader divides, where erosion has not been very active, and the more gradual slopes to drainage depressions.

The surface in general is undulating to nearly flat, but in the vicinity of the silt loam areas it becomes very gently rolling or sloping. Farm tractors can be used to advantage almost everywhere. Over much of the phase the run-off is through broad U-shaped intermittent drainage ways or swales. These have very low gradients, and much of the surface water sinks into the soil. Most of the type is tile drained in the flatter areas. Near the margin of the large area of this type and on some of the smaller ones, where the surface is more sloping and the stream gradients higher, the surface drainage is better. Internal drainage in general is slow, on account of the close structure of soil and subsoil, and tile drains are used in places to correct this. This soil is very retentive of moisture, and crops rarely, if ever, suffer from drought.

The Webster silty clay loam, when well drained, is one of the most desirable soils in the county for general farming. It includes no waste land, and practically all of it is under cultivation. The principal crops are corn, oats, hay, barley, and wheat. Corn is the principal money crop, with oats second in importance. About 50 per cent of the corn and 60 per cent of the oats produced are put on the market. As a rule corn matures a few days later than on the other upland types, owing to the necessity of planting later in the spring and to the slower development of the plants where the soil is poorly drained. Cultivated grasses are being grown more extensively each year in systematic rotations, and used in the feeding of live stock. Little alfalfa was grown on this soil until recent years, but good results have been obtained where the soil is well tiled. Practically all the orchards on this type are small. The main live-stock industries are the raising of hogs and the raising and fattening of beef cattle. Considerable pure-bred stock is kept in the vicinity of Greenville and Royal and in the southern part of the county. Dairying is not well developed, but interest in this branch of farming has been growing rapidly of late.

This soil is nearly as productive as the heavier alluvial types of the county, and crop yields are generally as high, or higher. The average yield of corn is about 40 bushels per acre. In very favorable years a yield of 65 bushels is not uncommon. Oats ordinarily yield 35 to 45 bushels, barley about 25 bushels, and spring wheat 18 to 23 bushels per acre. Little winter wheat has been grown until recently. It yields ordinarily 20 to 27 bushels per acre. Clover and timothy

mixed ordinarily yield about 2 tons of hay per acre, red clover alone 1¾ to 2 tons, timothy 1¼ to 1¾ tons, and alfalfa 2 to 3½ tons. Potatoes yield an average of about 87 bushels per acre.

The Webster silty clay loam is quite friable in the surface 6 inches, and its structure and high organic content permit it to be worked under a wide range of moisture conditions as compared with other silty clay loams. However, if plowed when too wet it forms clods that are rather slow to break down. In wet springs the soil frequently becomes so water soaked in depressions as to retard cultivation seriously.

By employing the proper methods of handling, such as are followed by the more progressive farmers, the productiveness of this soil can be easily maintained. Most of the farmers recognize the value of crop rotations and many follow a definite system, with excellent results. Corn is usually grown 2 years, a small grain 1 year, followed by red clover or mixed red clover and timothy for 2 years, after which the land is returned to corn. Often this is reduced to a 4-year rotation by growing corn only one year. When clover is grown primarily for soil improvement it is seeded alone. Many farmers report that the first crop of corn following clover yields 5 or 6 bushels more per acre than the second crop. Very few farmers have introduced alfalfa into the rotation, and where grown it is left for several years before the land is returned to corn. The best farmers keep enough live stock to supply considerable barnyard manure, and this is usually applied to clover sod that is to be plowed up for corn the following year. Some is applied to oat land before plowing.

The farms are in general well improved. Some of the best farms in the county are on this soil. Most of the farms are thoroughly tiled. Permanent wells can be obtained by drilling 100 to 250 feet deep. Dug wells ranging from 35 to 50 feet deep furnish water most of the year. Most of the farms range in price from $150 to $200 an acre. The value depends largely on the location, the condition of the land, and the improvements, of which the tile system is an important factor.

In improving this soil the first step is to insure thorough underdrainage. The success obtained with alfalfa in recent years on well-drained farms warrants a more extensive trial with this crop. It produces one or two more cuttings a year than red clover and gives a heavier yield. It also stands longer without reseeding. Not enough live stock is kept on some farms to produce sufficient manure to keep the soil in the best condition. The occasional turning under of a greeen-manure crop, such as red clover, would be of great benefit to the soil in such case.

In the following table are given the results of mechanical analyses of samples of the soil, subsoil, and lower subsoil of the Webster silty clay loam:

Mechanical analyses of Webster silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331411	Soil	0.0	0.3	0.3	5.6	12.4	59.6	21.7
331412	Subsoil	.0	.6	.3	2.5	13.3	56.4	26.9
331413	Lower subsoil.	.0	.2	.3	1.7	14.2	59.8	23.3

SHELBY FINE SANDY LOAM.

The surface soil of the Shelby fine sandy loam is usually a brown to grayish-brown fine sandy loam, extending to a depth of 10 or 12 inches and underlain to 36 inches by a rather compact, light-brown fine sandy loam to loamy fine sand, which grades into a light-brown, clayey fine sand at about 27 inches. The surface soil is not very high in organic matter, and has a dark yellowish brown to dark-brown appearance when wet. The subsoil frequently shows reddish-brown iron strains and occasionally contains small lime concretions. In places glacial pebbles and small bowlders occur on the surface and throughout the soil section. Frequently the bowlders are so numerous as to interfere with cultivation.

This is a typical morainic soil, and both surface soil and subsoil are quite variable. Within a single area the surface soil may vary from a fine sand to a light loam, and in a few places in Logan Township small knobs of bowlder clay, too small to separate, occur in the center of a typical area. In a few spots the surface soil is underlain directly by a fine sand, which rests upon a substratum of bowlders and gravel at about 30 inches. In part of the area in section 6, Waterford Township, the subsoil of brown fine sandy loam is underlain at 16 or 18 inches by a brown substratum of bowlders, gravel, and sand, without stratification.

The Shelby fine sandy loam occurs principally in the eastern fourth of the county, on morainic hills, knolls, and ridges within areas of the Carrington fine sandy loam and the Carrington loam. One area is mapped in the northwestern corner of the county. Few, if any, of the areas are as large as 1 square mile, and with the exception of four comparatively large areas, one in the northwest corner of the county, a second along Elk Creek, a third in the south-central part of Herdland Township, and a fourth near Elk Lake, they are quite small.

The surface of the larger areas is for the most part hilly and rolling, and of the smaller areas, knolly or ridgy. Surface drainage is

well established, and erosion is active in places on the steeper slopes. Internal drainage in most places is excessive, owing to the open, loose nature of the subsoil. Frequently crops suffer from lack of moisture in the drier seasons. In some places the subsoil is more compact than usual, and water is more readily retained.

The Shelby fine sandy loam is not very important agriculturally. Less than one-third of it is under cultivation, the remainder being used as grazing land. Like most of the other upland types this soil originally supported a growth of prairie grass, with little or no timber.

On account of its rolling topography and, in places, the large number of bowlders on the surface grazing is the only agricultural use that can be made of much of this soil. The most important live-stock industry is the pasturing of beef and dairy cattle. Hogs are raised to some extent in the less rolling situations. A small total area is under cultivation. Corn is the principal crop, followed by oats, hay, barley, and wheat. Small grains are grown more extensively in proportion to corn than on the other soils of the county. Yields average a little lower than on the Carrington fine sandy loam, but in the areas of more compact subsoil they are as high, if not higher. The Shelby fine sandy loam is handled in much the same way as the Carrington fine sandy loam. The farmers realize the greater need of organic matter, and practically all the manure produced is put back on the soil.

Few farms are made up entirely of this soil. It usually has a somewhat lower selling price than the Carrington fine sandy loam, although a few of the better areas command equally as much. The value varies considerably with the condition of the soil, the topography, the location, and the improvements.

More manure than is produced on the average farm is necessary to supply the need of this soil for organic matter. Leguminous crops should be grown more extensively, and an occasional crop turned under. Good results would follow the more general adoption of definite crop rotations. The steeper slopes should be kept in cover crops to help prevent erosion.

The results of mechanical analyses of samples of the soil and subsoil of the Shelby fine sandy loam are given in the following table:

Mechanical analyses of Shelby fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331421	Soil	3.2	7.4	5.4	23.5	13.0	28.0	19.5
331422	Subsoil	2.0	5.6	4.8	22.2	14.6	31.3	18.9

WAUKESHA SILT LOAM.

The Waukesha silt loam differs from the O'Neill loam in having a stratum of sand and gravel within the 3-foot section. It also differs in this county in having a higher content of organic matter and a darker surface soil. The type consists of a dark-brown, moderately heavy silt loam, about 15 inches deep, underlain by a subsoil of yellowish-brown to brownish-yellow, compact, light, silty clay loam, which becomes more friable as the 3-foot depth is approached. This subsoil material continues to a depth of 5 to 10 feet, where the basal material, usually consisting of sand and gravel, is reached. In the smaller areas the type may be underlain by the same basal material as the upland soils. The surface soil is moderately high in organic matter and usually contains considerable fine sand. Frequently a small quantity of glacial gravel occurs throughout the 3-foot section. The upper soil section is usually leached, but traces of lime are occasionally present in the lower depths, as indicated by the hydrochloric-acid test.

The Waukesha silt loam occurs in a few small, scattered areas in Lake and Meadow Townships. One of the largest two areas lies immediately south of Trumbull Lake, and the other one-half mile west of Langdon. The type occupies distinct benchlike areas or outwash terraces, lying 10 to 15 feet above the first bottoms and almost entirely above overflow. The surface is nearly flat, but is fairly well drained. The rather compact subsoil retains moisture well, and the type resists drought over long periods.

About 75 per cent of the Waukesha silt loam is under cultivation. Nearly all the smaller areas are used for pasture. The type originally supported a growth of the common prairie grasses. The same crops are grown as on the Carrington silt loam, and similar yields are obtained. Ordinarily this type is handled in much the same way. It is a little more mellow, and cultivable under a wider range of moisture conditions.

The selling price of land of the Waukesha silt loam is ordinarily the same as that of the adjacent upland soil, with which it is usually farmed.

Farm methods that can be used to improve the Carrington silt loam are likewise beneficial to this type.

O'NEILL FINE SANDY LOAM.

The surface soil of the O'Neill fine sandy loam is a dark-brown to dark grayish brown fine sandy loam, 8 or 10 inches deep. It is underlain by a light-brown to brown, rather compact fine sandy loam to loamy fine sand, which grades into a light-brown fine sand at about 16 inches. The surface soil is moderately high in organic matter, except where it has been cropped continuously without

manuring; here it is grayish brown in color. The areas in the vicinity of Trumbull and Mud Lakes have considerable coarse sand and gravel throughout the soil section. A few of the other areas have a noticeable content of coarse sand and gravel, but as a rule the texture is fine sand.

The O'Neill fine sandy loam is rather inextensive in Clay County. It occupies narrow, rather flat minor elevations, lying 10 to 15 feet above the typical O'Neill loam. None of the areas are very large. Surface drainage is poorly developed, most of the water sinking through the soil. The generally porous subsoil is not very retentive of moisture, and crops on this soil are usually the first to suffer in dry seasons.

The O'Neill fine sandy loam is not very important agriculturally. Much of it supports a sparse growth of the native prairie grasses and is used as pasture. Approximately 75 per cent is under cultivation. It is usually cultivated in fields with the O'Neill loam, and is handled in much the same manner as that soil. The more successful farmers grow small grains in preference to corn. Clover and alfalfa do very well when once started. Yields of the different crops vary considerably with the season and with the water-holding capacity of the soil from place to place. They are usually lower than on the O'Neill loam. In the areas of more compact subsoil, where conditions are more favorable for the retention of moisture, yields are about as high as on the loam.

Land of this type is usually sold in farms with the adjacent types, principally the O'Neill loam or Carrington loam. When sold alone it has a lower value.

Generous applications of barnyard manure or the plowing under of green-manure crops would do much to make this soil more retentive of moisture and to increase the crop yields.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the O'Neill fine sandy loam:

Mechanical analyses of O'Neill fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331407	Soil	1.2	10.4	12.8	34.0	8.2	19.2	14.0
331408	Subsoil	.2	7.5	13.4	47.7	11.1	11.8	8.2

O'NEILL LOAM.

The O'Neill loam consists of a dark-brown to dark grayish brown, mellow loam, about 8 inches deep, underlain by a light-brown to brown, rather compact loam to light silty clay loam. This gradually

becomes sandier until a bed of stratified sand and gravel is encountered, usually at a depth of about 27 inches. This bed is quite uniformly 25 to 30 feet in thickness, and lies on a layer of blue clay. It may consist largely of gravel with pockets of sand, or may be mostly sand with thin layers of gravel. In either case it is practically free from clay particles, except in the upper few inches. Occasional gravel particles also occur in the soil and upper subsoil.

In some places back from the streams or adjacent to the uplands, where the bed of gravel may be nearer the 3-foot depth, the surface soil is quite silty. Near the streams, or where run-off or wind erosion has been active enough to remove part of the surface covering, the coarse-textured stratum comes near the surface in places, and the surface soil is lighter colored and lighter textured than typical. Small ridges of O'Neill fine sandy loam occur in places too small to map separately. Some of the areas in the vicinity of the old lakes include small mounds, rarely over 150 feet in diameter, which consist of a gravelly sandy loam at the surface, underlain by a subsoil which is typical except for the presence of small bowlder fragments. The surface soil of the O'Neill loam is not as high in organic matter as that of the heavier Carrington soils.

The O'Neill loam is most extensively developed along the Little Sioux and Ocheyedan Rivers from Dickens to Everly and from Spencer north to the county line, where it occupies an area aggregating 40 or 45 square miles, interrupted only by the rivers and the smaller streams issuing from the upland. Smaller areas occur along some of the other streams of the county and near the old lakes. The basal material of the smaller areas and of the large area near Spencer was probably formed by the deposition of sand and gravel on the beds of old lakes which have been drained at a comparatively recent date, the loessial surface covering being subsequently laid down by anteglacial inundations or winds. The basal material of the remaining areas was either deposited in the same way, on a smaller scale, or was laid down by swift glacial streams.

The type usually lies 10 to 20 feet above the overflow bottom land, in rather flat, distinctly benchlike areas. One area, however, on the west side of the Little Sioux Valley just south of the north county line, lies on an older terrace 15 or 20 feet above the typical terrace level. The smaller areas of the type ordinarily do not lie as high above the first bottoms as the larger areas. Near the center of Garfield Township, close to the drained area which was formerly Mud Lake, an area of the O'Neill loam lies 20 to 40 feet below the upland and about 20 feet above the old lake bed. The elevation of the type at Spencer is 1,010 feet above sea level.

The O'Neill loam has little surface drainage, most of the water escaping through the subsurface layers. Where the substratum of

gravel and sand lies near the surface the drainage is inclined to be excessive, but over most of the type the surface soil and upper subsoil are fairly retentive of moisture. The type, however, is not as retentive as the other important soils of the county, and in years of prolonged dry spells during the growing season crops are apt to suffer.

The O'Neill loam is the most extensive alluvial soil in the county, and it is of considerable importance agriculturally. Originally it supported a characteristic prairie growth, with practically no trees or shrubs. Probably 80 per cent of the soil is under cultivation. The remainder is used for pasturage or has been laid out in town sites and farmsteads.

The principal money crop on this soil is corn. Oats are of second importance, followed by hay, barley, and wheat. The various crops are of about the same relative importance as on the Carrington loam, but cultivated grasses are grown more extensively, and wheat less extensively, in proportion to the other crops. The raising of hogs and the raising and fattening of beef cattle are the most important live-stock industries. Some sheep are raised and fattened. Several carload lots of western cattle and sheep are annually fattened in the vicinity of Everly and Spencer. Considerable dairying is done near the towns.

In the average year corn yields 25 to 36 bushels per acre, oats 25 to 35 bushels, barley 18 to 20 bushels, spring wheat 14 to 20 bushels, and winter wheat 18 to 22 bushels. In more favorable years the yields are much higher, and this soil is nearly as productive as the better upland types. Where the gravel layer occurs in the lower part of the 3-foot section, clover and timothy give as good yields as on the Carrington loam, and alfalfa does nearly as well. Potatoes yield 80 to 100 bushels per acre. Very little fruit is grown.

It is possible to get the maximum benefit from farm machinery on the O'Neill loam, owing to its flat surface and to the wide range of moisture conditions under which it can be worked. Crops are more generally rotated than on some of the upland types, corn being grown but one year and the land being put into a leguminous crop as often as possible. Tillage methods are practically the same as on the Carrington loam, except that tractors are more commonly used for the heavier tillage operations.

Farms on the O'Neill loam are generally well improved. Permanent water is obtained in dug wells at depths ranging from 15 to 40 feet. The land sells for $125 to $150 an acre, except in the vicinity of towns, where it may be higher.

The O'Neill loam has a lower organic content than most of the upland soils, and there is a greater need for the application of barnyard manure or the frequent turning under of a green crop.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the O'Neill loam:

Mechanical analyses of O'Neill loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331409	Soil	2.4	8.9	5.4	10.0	6.4	42.8	23.9
331410	Subsoil	2.2	9.8	6.0	13.0	8.6	37.5	22.7

FARGO SILTY CLAY LOAM.

The soil of the Fargo silty clay loam is practically the same as that of the Lamoure silty clay loam. It consists of a very dark brown to nearly black, heavy silty clay loam, underlain at about 18 inches by a dark-drab, heavy silty clay loam which becomes lighter in color with increasing depth and has a yellowish cast. The surface soil is high in organic matter, but not as high as the Lamoure soil. Both surface soil and subsoil are quite uniform, and highly calcareous, the lime occurring as concretions and lime specks.

The Fargo silty clay loam is not very extensive. It occurs mainly in the western part of Lake Township. An area is mapped in section 3, Logan Township. The type lies 10 to 15 feet above the Lamoure silty clay loam. Its surface is nearly flat or gently sloping from the upland to the Lamoure soil of the bottom lands. Drainage, while not adequate, is better established than on the Lamoure soil, and in most places water does not stand on the surface. Artificial drainage of the subsurface material is necessary for the best crop production, owing to the heavy and rather compact nature of both surface soil and subsoil.

This is a rather important type agriculturally. About 80 per cent of it is drained and under cultivation, the remainder supporting a growth of the native prairie and slough grasses and being used as hay and pasture land. Practically the same crops are grown as on the Webster silty clay loam, deep phase, and the yields are approximately the same. Hog raising and the raising and fattening of beef cattle are the most important live-stock industries. Some dairying is carried on.

The Fargo silty clay loam is farmed in much the same manner as the Webster silty clay loam. Like that soil it must not be worked when wet, owing to the tendency to form clods which are rather slow to break down. When a dust mulch is not maintained during the drier seasons, there is a tendency for the soil to crack. Very little manure is used on this type. The land usually sells for $125 to $150 an acre.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Fargo silty clay loam:

Mechanical analyses of Fargo silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331423	Soil	0.5	3.6	3.6	15.6	10.0	42.1	24.6
331424	Subsoil	.2	3.2	3.4	15.4	11.0	42.6	24.0

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$) : No. 331423, 1.68 per cent; No. 331424, 11.52 per cent.

WABASH LOAM.

The Wabash loam consists of a dark-brown to dark grayish brown, rather mellow loam, underlain between the depths of 20 and 40 inches by a brownish-gray, compact heavy loam to sandy silt loam. In the areas of poorest drainage the subsoil is often a silty clay loam, lighter in color in the lower depths. The surface soil is quite high in organic matter, though not as high as that of the Wabash silt loam. It varies considerably in texture even within a single area, the lower lying, more frequently overflowed land next to the stream channels being somewhat sandier than typical. Farther back, where it is not changed as frequently, the soil is heavier, being even silty adjacent to the heavier upland types. More fine sand is present in all cases than the other grades of sand. In areas adjacent to the O'Neill loam gravel may occur in small quantities throughout the soil section.

The Wabash loam occurs mainly along Willow Creek and along the Little Sioux River near Peterson. Smaller areas are encountered along the various tributaries. In the larger areas the soil occurs in narrow strips occupying all, or nearly all, the first-bottom land. Elsewhere it is usually developed in the bends of the streams. Most of the type lies nearly flat, and slightly lower than the Wabash silt loam. Like that type it is more or less subject to overflow. The areas along the lower course of the Little Sioux are either flat or slope gently from the adjacent uplands. The sloping land is rarely overflowed. Most of the lower lying areas, especially along the river, are dissected by old sloughs and channels. Drainage as a rule is rather poor, but better than on the Wabash silt loam, owing to the more open structure of both surface soil and subsoil. In wet seasons water often stands on the surface for considerable periods along the creeks.

Less than 15 per cent of the Wabash loam is under cultivation. Most of the type along the creeks and along the upper courses of the

rivers is used as hay and pasture land, owing to the frequent overflows. In the broader and more sloping areas in the southern part of the county much of it is under cultivation, the remainder being either in the native grass or supporting a forest growth, chiefly basswood, cottonwood, willow, ash, and box elder.

The Wabash loam is devoted to the same crops as the Wabash silt loam, and gives approximately the same yields. Some alfalfa is grown in the higher lying areas. It ordinarily yields 2 to 2½ tons of hay per acre per season in well-drained situations above overflows. The soil is naturally productive, and in wet years small grains are inclined to grow too rank. Potatoes give an average yield of about 90 bushels per acre.

This soil can be worked under a wider range of moisture conditions than the Wabash silt loam. It usually turns up very mellow from the plow. The type is usually farmed in conjunction with the adjacent upland soils, chiefly the Carrington loam or silt loam, and it is handled in much the same way. Little manure is used.

Where this type occurs in well-drained areas large enough to form separate fields the land sells for $100 to $150 an acre.

This soil could be greatly improved by the methods that are beneficial on the Wabash silt loam. There is a greater need for the addition of organic matter, owing to the more open nature of both surface soil and subsoil.

WABASH SILT LOAM.

The Wabash silt loam consists of 18 or 20 inches of dark-brown to nearly black, heavy silt loam, underlain to a depth of 40 inches by a brownish-gray, rather compact, heavy silt loam to light silty clay loam. The change in color and texture from surface soil to subsoil is very gradual, and often imperceptible. In some places there is no change within the 3-foot section, except for possibly a higher percentage of clay in the lower depths. In the better drained areas faint brownish iron stains often occur in the lower subsoil. The surface soil is high in organic matter, but not as high as in the case of the Lamoure soils.

Along the upper course of the Ocheyedan River the surface soil is heavy, approaching a silty clay loam, and the subsoil is a very compact silty clay loam. Along the lower course of the Little Sioux River the surface soil in many places contains considerable sand, and becomes a very mellow silt loam. Numerous areas of Wabash loam too small to map are included with this type in the lower lying situations or in old bends of the river channel. In places there is very little difference between this type and the Lamoure silty clay loam except in lime content. The boundary lines separating the two soils are rather arbitrary, many small areas of the Lamoure soil being included with this type.

The Wabash silt loam occurs mainly in narrow strips lying close to the channel of the Ocheyedan River and occupying nearly the whole of the first bottom along the Little Sioux River and the lower courses of its larger tributaries. The strips are in few places as much as one-half mile wide along the lower course of the Little Sioux. The surface of the type is nearly flat, frequently dissected by old stream channels and sloughs, and drainage in general is rather poor. Practically all the type is subject to occasional overflows, as it lies only 4 to 10 feet above the normal water level of the streams.

Along the upper courses of the rivers water often stands on the surface for a considerable period after each inundation or heavy rain. Along the lower course of the Little Sioux River the type lies higher, is less frequently overflowed, and has better drainage. Some areas in the southern part of the county are well covered with ash, soft maple, basswood, willow, box elder, and cottonwood, and there is a more or less continuous, narrow strip of these trees bordering the river as far north as Spencer.

Probably less than 10 per cent of the Wabash silt loam is under cultivation. The remainder is still in native grasses and is used as pasture and hay land. Only the higher lying and better drained areas are cropped. Corn is the principal crop, with clover and timothy ranking second. Small grains are grown only about once in 5 or 6 years, owing to their tendency in wet years to grow too rank and lodge. Practically no alfalfa has been grown on this soil, but the crop should do well in the better drained areas. Wild grasses yield 1 to $1\frac{3}{4}$ tons of hay per acre, and clover and timothy about $2\frac{1}{4}$ tons. Where the land is well drained and protected from overflow corn usually yields 40 to 45 bushels per acre, oats 35 to 45 bushels, and spring wheat 20 to 25 bushels.

The Wabash silt loam where well drained can be handled as easily as the Carrington silt loam, and in the areas of more mellow structure it can be tilled under a wider range of moisture conditions, as it is less inclined to clod. Corn is grown successfully for longer periods than on the Carrington soil, and definite crop rotations are not as generally practiced. Very little manure is applied to the soil.

As the greater part of this type is more or less subject to overflow and as the surface is broken frequently by old channels, the soil is considered of more value as grass land than for cultivated crops. It sells for $100 to $125 an acre.

Little of this soil has been tile drained. The establishing of a good system of surface drainage and underdrainage is a prerequisite in the growing of cultivated crops. Straightening and deepening the streams, as has been done along the upper course of the Ocheyedan River, would lessen the frequency of overflows and decrease the crop

losses from that cause. Diking may be required to give adequate relief in some places.

LAMOURE LOAM.

The surface soil of the Lamoure loam, extending to a depth of 12 or 15 inches, is a nearly black loam, very high in organic matter. It is underlain by a dark brownish drab to dark yellowish drab silty clay loam, which grades at about 30 inches into a yellowish-drab to drab sandy clay to clayey sand. This usually contains considerable coarse sand. The entire 3-foot section is highly calcareous, the lime often occurring in the surface soil as small particles, and in the subsoil in the form of small concentrations or chalky balls. Reddish-brown iron stains occur in the upper subsoil. In a few places the soil is nearly black through the entire 3-foot section.

This soil is not extensive. It occurs mainly in small areas scattered over the northeastern fourth of the county, principally to the north of Spencer. The type has a flat surface and is poorly drained. Very little of it has been put under cultivation. It remains largely in the native slough grass and is used for pasture and hay land. Where cultivated it is devoted to the same crops as the Lamoure silty clay loam, and yields approximately the same as the latter type.

This soil usually occurs in fields with the Lamoure silty clay loam, and it is handled in much the same manner. It can be worked under a wider range of moisture conditions, and does not clod or bake badly on drying. The selling price of the land is practically the same as in the case of the silty clay loam.

The farming methods that are beneficial on the Lamoure silty clay loam can be used with equally good results on the Lamoure loam.

LAMOURE SILTY CLAY LOAM.

The surface soil of the Lamoure silty clay loam is a very dark brown to nearly black silty clay loam, high in organic matter. The subsoil, commencing at about 20 inches, consists of a dark-drab to brownish-drab silty clay loam which becomes lighter drab with increasing depth. As a rule, both the surface soil and subsoil are highly calcareous, the lime occurring as small, macroscopic particles. In many places the subsoil also contains small lime concretions and chalky material. Brownish iron stains are numerous in the subsoil in the better drained areas.

Near the areas of Muck and Peat lying in the center of some of the larger areas of the type the surface soil in many places contains a large quantity of peaty material with an admixture of varying quantities of silt and clay in the surface 3 or 5 inches. When the peaty material is over 5 inches deep the soil is mapped as Muck and

Peat. In the narrower areas adjacent to sandy upland types the surface soil may become sandy enough to be a loam, while it may approach a clay loam in the center of the wider areas. When dry the surface soil often has a smooth feel, owing to its high organic content, but when wet it becomes sticky. In many of the areas on the terraces and near the lakes the subsoil varies from typical in that it assumes a yellowish cast and grades below 30 inches into a yellowish-drab to drab sandy clay or clayey sand, which occasionally includes spots of greenish-colored material. In some of the areas in the main upland the subsoil has a yellowish cast, but here it is rarely sandy in the lower part. In places along the lower courses of the larger streams and near the center of some of the larger areas there is little apparent difference between the surface soil and the subsoil except in organic content, the almost black color and silty clay loam texture continuing throughout the 3-foot section.

Small strips of faintly alkali soil occur in the Lamoure silty clay loam in places, usually surrounding Peat deposits or along recently drained areas. Crops do not give satisfactory yields here. In some of these strips the surface material shows a very thin whitish incrustation when dry, as a result of the deposition of salts as the water evaporates. Occasionally a small quantity of salt crystals may be encountered in the lower subsoil. The alkali consists of a mixture of calcium and sodium salts.[1] The total area of alkali soil in this county is very small. The individual strips are rarely more than 80 feet wide.

The Lamoure silty clay loam consists of fine sediment washed down from the gentle drift-covered slopes and deposited by slowly moving currents or in depressions containing stagnant water. It occurs in narrow strips along sloughs and sluggish drainage ways, in larger strips along the upper courses of the river, and near stream heads in irregular patches which often appear to be old glacial-formed lake-like marshes, recently drained. Much of the type occurs on the broad high terrace in the north-central part of the county.

The surface of the Lamoure silty clay loam is nearly flat, and drainage is naturally poor. In most of the unreclaimed areas water stands on the surface for some time after heavy rains. Near most of the smaller stream channels the type is subject to annual overflow unless properly ditched. The greater part of the type along the Ocheyedan River has been overflowed but once in 5 or 6 years, since the river was ditched and straightened.

The Lamoure silty clay loam is the most extensive first-bottom type in the county, and it is very important agriculturally. Where not drained it supports a luxuriant growth of slough grass, which furnishes excellent pasturage and hay. Probably more than 85 per cent

[1] See Bul. No. 157, Improving Iowa's Peat and Alkali Soils, by the Iowa Agr. Expt. Sta.

of its total area is still undrained, but the value of tile drainage has been thoroughly demonstrated and more of the type is being reclaimed each year. About 75 per cent of the total area in native grass is used for pasture. Corn is the principal crop, with oats ranking second, followed by clover, timothy, barley, wheat, and flax. Very little winter wheat is grown, and practically no alfalfa. The feeding of beef and dairy cattle is the principal live-stock industry, though considerable hog raising is done. Several large pastures are maintained in the wider areas of the type, and more pasturing is done on this soil than on any other in the county. Slough grass ordinarily yields 1 to 1½ tons of hay per acre. With good drainage corn yields in normal years 40 to 50 bushels per acre, oats 35 to 45 bushels, barley about 25 bushels, and spring wheat about 20 bushels. Flax yields 8 to 10 bushels per acre.

The Lamoure silty clay loam requires as heavy draft for tillage as the Webster silty clay loam. It is inclined to bake and crack in dry seasons, but the high organic content tends to prevent the formation of clods, and a good tilth can be maintained with seasonable treatment. After the soil is drained and broken the first crop grown is usually flax. This is followed by oats, as the soil is still very intractable and not well suited to corn planting. After the second year the rotation usually practiced on the Webster silty clay loam is followed, except that corn is grown longer in succession. Small grains are grown as little as possible on the newer fields, owing to their tendency to grow too rank. Little or no barnyard manure is used on this soil.

Land of the Lamoure silty clay loam where thoroughly drained sells for $160 to $180 an acre. The undrained areas ordinarily sell for $100 to $125 an acre. This soil is usually included in farms with adjoining types.

In the improvement of this type the first need is the establishing of thorough drainage. Farmers who have improved the land with tile drains report that a thorough drainage system will return the cost of installation in a few years. This soil is naturally very productive, but it should not be cropped too long without the addition of manure or organic matter. The most satisfactory method of preventing the surface appearance of alkali and of ridding the soil of the harmful salts, as reported by farmers, is to lay a sufficient number of lines of tile around the margin of the affected area to carry away the soil water rapidly. To aid in hastening the removal of the salts after the drainage system has been established, the Iowa Agricultural Experiment Station recommends the liberal application of barnyard manure or the plowing under of straw and green crops, to produce acids which react with the salts.

In the following table are given the results of mechanical analyses of samples of the soil and subsoil of the Lamoure silty clay loam:

Mechanical analyses of Lamoure silty clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
331427	Soil	0.2	0.9	1.1	9.0	11.7	52.1	25.1
331428	Subsoil	.6	2.2	3.0	11.4	10.4	49.6	22.8

The following samples contained more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 331427, 8.93 per cent; No. 331428, 1.22 per cent.

MUCK AND PEAT.

The surface material of Muck and Peat consists of 6 to 24 inches of dark-brown to black, partly decomposed organic matter derived from water-loving plants and grasses, with a small admixture of silt, clay, or very fine sand washed from the adjoining slopes. Its average depth is about 12 inches. The underlying material is a nearly impervious, drab silty clay or clay. This is darker in the upper part, owing to the presence of considerable organic matter. The subsoil is highly calcareous. In a few places a yellowish-drab mixture of clay, sand, and gravel underlies the dark-drab subsoil at about 27 inches. Muck and Peat differ only in the stage of decomposition of the vegetable matter. Muck is black in color, the vegetable matter is well decomposed and finely divided, and it contains considerable mineral matter, mostly of fine grades.

Muck and Peat occurs in old sloughs or lakelike depressions whose drainage outlets have become obstructed in some manner and in which the decomposition of the accumulating plant growth has been retarded by subsequent deposits and by conditions of poor drainage. The material in many places is fibrous, retaining the structure of the plants. Many of the areas have been drained by the deepening of the drainage outlets. Areas where water still stands on the surface are indicated on the map by marsh symbols.

The four largest areas of Muck and Peat occur, respectively, southwest of Lost Island Lake, southwest of Webb along Montgomery Creek, in the west-central part of Lake Township, and in the bed of Mud Lake, in sections 25 and 26, Garfield Township. The areas in Mud Lake and along Montgomery Creek have been recently drained by large ditches. Smaller areas of Muck and Peat occur over the eastern tier of townships. Patches too small to map lie in the Lamoure silty clay loam in this part of the county. The surface of the type is practically level and the natural drainage poor.

Muck and Peat cover a total area of 5.5 square miles, but probably less than 320 acres have been put under cultivation. About 10 per cent of the total area has been drained in the last two years, and projects are under way for draining of much of the remainder in the near future. It has been found that corn and small grains can not be grown as profitably at first as timothy and clover. Corn is usually stunted and the small grains are inclined to produce straw at the expense of grain. The yields of timothy and clover are as high as those obtained on the upland soils, and in some cases higher. Most of the type where not too wet is used for pasture. It has been found that the best practice after draining this land is to seed it to grass and pasture it heavily for several years before sowing to grain crops. Pasturing the land with a large number of animals serves to compact the soil.

Practical methods for the improvement of shallow peat deposits in northern Iowa, as suggested by the Iowa Agricultural Experiment Station[1] include thorough drainage, deep fall plowing to expose the soil to the effects of freezing, and frequent cultivation during the summer to hasten decomposition. Timothy and alsike clover are suggested as the crops best suited to the areas newly reclaimed. Experiments show that while the peaty material may be deficient in lime, potash, and phosphorus, there is sufficient in the subsoil to supply crops, and the application of commercial fertilizers has not proved profitable.

SUMMARY.

Clay County is situated in the northwestern part of Iowa. Its surface is that of a broad, undulating glacial-drift plain. The eastern fourth of the county is somewhat knolly or ridgy. A considerable area of high terrace land is developed along the larger streams. Drainage is rather slow over most of the county. The greater part of its area is drained by the Little Sioux River into the Missouri River; the remainder drains into the Mississippi. The average elevation is between 1,060 and 1,100 feet above sea level.

The first settlement in this territory was made in 1856, near Peterson. The population has steadily increased and in 1915 amounted to 14,656. Nearly 94 per cent of the area of the county is reported in farms.

The county has good railroad facilities and is well supplied with shipping points. The most important trading centers are Spencer, Everly, Dickens, Peterson, and Webb. Spencer is a good market for wheat. The principal large outside markets are Chicago, Minneapolis, St. Paul, Sioux City, Omaha, and Milwaukee.

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

The mean annual rainfall is 29.62 inches. The precipitation is quite favorably distributed for the growth of crops. The mean annual temperature is 45.4° F. There is an average growing season of 156 days.

A highly developed system of general farming prevails throughout the county. The principal crops are corn, oats, clover, timothy, barley, and wheat. Corn is the principal money crop. Hog raising is the most important live-stock industry. Several carloads of cattle and sheep are brought in annually for fattening. Dairying has received little attention until recently.

There were 1,651 farms in Clay County in 1915, with an average size of about 203 acres. Less than one-half of all the farms are operated by owners. Farm land rented for cash brings $5 to $7 an acre annually. Efficient farm labor is somewhat scarce over most of the county. Farm laborers receive $30 to $35 a month with board and washing.

Land values in Clay County range from $100 to $225 an acre, with $150 an acre as the average price.

The soils of Clay County may be broadly divided into three general groups, viz, upland soils, high-terrace soils, and first-bottom soils. Including Muck and Peat, 14 types of soils, classed in 8 series, are recognized.

The upland division is made up of dark-colored glacial-drift soils, classed in the Carrington, the Webster, and the Shelby series. The Carrington silt loam and loam make up the greater part of the upland. The Shelby soils differ from the Carrington and Webster soils in having more sand and gravel in the subsoil.

The Carrington silt loam is nearly as important as the Webster silty clay loam for corn growing. It is devoted to the same crops as the heavier types. The Carrington loam covers most of the upland in the northern and eastern two-thirds of the county. It is devoted chiefly to corn. Small grains are grown more extensively in proportion to corn than on the heavier types. The steep phase of the Carrington loam occurs along stream slopes in the southern part of the county, and is devoted mostly to grazing. The Carrington fine sandy loam occurs principally in areas of the Carrington loam. Owing to its rather open, porous nature it is in most places less productive than the loam.

The Webster silty clay loam is the most important corn soil in the county. Other crops grown are oats, clover, timothy, barley, and wheat.

The Shelby fine sandy loam occurs on morainic hills, knolls, and ridges, mainly in the eastern tier of townships. It is used largely as grazing land, on account of its rolling surface and rather droughty nature.

The high terrace or second bottom soils are classed in the O'Neill, Fargo, and Waukesha series.

The O'Neill loam is rather extensive, occupying an area of about 45 square miles in the vicinity of Spencer. It is inclined to be more droughty than the other important soils of the county, but gives good yields in normal years. The O'Neill fine sandy loam occurs on minor elevations in areas of the O'Neill loam. In general it is not as productive as the loam.

The Waukesha silt loam is an inextensive soil, similar to the Carrington silt loam, in productive capacity.

The Fargo silty clay loam is a dark-colored, poorly drained soil. It has a higher lime content than the Waukesha silt loam.

The first-bottom soils are classed in the Lamoure and Wabash series. The Lamoure silty clay loam is the most extensive first-bottom soil in the county. It is used mainly as pasture and hay land. Where thoroughly drained it gives very good yields of grain crops. The Lamoure loam is an inextensive soil used chiefly for pasture and as hay land.

The Wabash loam and silt loam occur in narrow strips along rivers. Where well drained and protected from overflow they give excellent yields. These soils are devoted largely to pasture grasses.

Muck and Peat represents accumulations of vegetable matter occurring mainly in beds of old lakes or sloughs. With drainage these soils afford good pasturage, and by careful treatment for reclamation may be made highly productive after several years.

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