U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF SOILS.
IN COOPERATION WITH THE IOWA AGRICULTURAL EXPERIMENT STATION.

SOIL SURVEY OF DICKINSON COUNTY, IOWA.

BY

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[Advance Sheets—Field Operations of the Bureau of Soils, 1920.]

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[PUBLIC RESOLUTION—No. 9.]

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

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

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

Approved, March 14, 1904.

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

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MAP.

Soil map, Dickinson County sheet, Iowa.

SOIL SURVEY OF DICKINSON COUNTY, IOWA.

By J. AMBROSE ELWELL, of the United States Department of Agriculture, In Charge, and J. L. BOATMAN, of the Iowa Agricultural Experiment Station.

DESCRIPTION OF THE AREA.

Dickinson County, Iowa, is in the northern tier of counties of the State and is the third county east of the South Dakota boundary. Jackson County, Minn., bounds it on the north, Emmet County, Iowa on the east, Clay County on the south, and Osceola County on the west. Sioux City, Iowa, about 100 miles southwest, is the nearest city of importance. The county is rectangular in shape, and has a length of 24 miles and a width of about 17 miles. It comprises a land area of 376 square miles, or 240,640 acres. Its lake area, according to the State land office report of 1916, is 15,364 acres, or about 24 square miles.

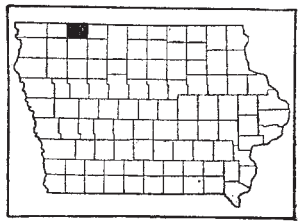

FIG. 19.—Sketch map showing location of the Dickinson County area, Iowa.

The principal topographic boundary in the county runs across the county from a short distance south of Stony Lake, passing south of Sylvan, Pratt, and West Okoboji Lakes, thence southeast to section 15, Milford Township, thence northeast parallel to Bull Ditch to the vicinity of Superior, and thence eastward to the county line. It divides the county into a northern rolling to hilly region and a southern smooth one. The smoothest part of the southern area lies in the extreme southern townships.

The first bottoms of the streams are level and elevated but slightly above the channels. These alluvial lands are of disproportionate width, except the narrow bottoms along the Little Sioux River through Silver Lake, Lakeville, and Okoboji Townships, where the bordering bluffs restrict the river to a valley less than one-fourth mile wide.

The general slope of the county, as shown by a number of known altitudes, is toward the south, and the general elevation ranges between 1,400 and 1,500 feet above sea level.

The valley of the Little Sioux River is the only one in the county that has been cut to any marked extent below the general upland level. The level of its channel is from 50 to 70 feet lower than the uplands in its upper course and 75 to 125 feet lower in its lower course in Okoboji Township. It has an average fall of about 3 feet per mile, and is the swiftest stream in the county.

Dickinson County was organized in 1857. The first unofficial census in 1859 reported a population of 121. The majority of the first settlers came from eastern Iowa; a few came from Illinois and States farther east. For 10 years settlement was slow. Indian

troubles were encountered at the outset, culminating in the historic Spirit Lake massacre. The Civil War also retarded settlement. From 1869 on the population steadily increased.

The census of 1920 reports the population as 10,241. The population is classed as rural and is evenly distributed, with an average density of 27.3 persons per square mile. Spirit and Okoboji Lakes are popular summer resorts, which annually attract a floating population of about 20,000 to 30,000. All of the inhibitants are white, and most of them are native born. Germans, Norwegians, Swedes, Danes, English, and Irish comprise the bulk of the relatively small percentage of foreigners.

Within the county are seven incorporated towns. The county seat, Spirit Lake, has a population of 1,701; Milford, 908; Lake Park, 789; Arnolds Park, 478; Terrill, 440; Superior, 200, and Orleans, 123.

Three railroads furnish excellent shipping facilities for all except the southwestern part of the county. A branch of the Chicago, Rock Island & Pacific Railway from Cedar Rapids, Iowa, to Sioux Falls, S. Dak., runs east and west through the northern part of the county. A branch of the Chicago, Milwaukee & St. Paul Railway from Des Moines runs north and south through the center of the county, and the Minneapolis & St. Louis Railroad taps the southeastern part of the county. These roads supply direct transportation to the terminal markets of Minneapolis, St. Paul, Chicago, and Des Moines, and connections with Omaha and Sioux City.

Three graveled highways north and south and three east and west provide all sections with good roads for marketing in all seasons of the year. With 53 rural schools, 8 of which are consolidated, and 1 township high school, excellent educational facilities are available.

Superior is the local market for the northeastern part of the county, Terrill for the southeastern part, Milford for the south-central and southwestern part, Spirit Lake and Montgomery for the north-central part, and Lake Park for the northwestern part of the county.

CLIMATE.

The best Weather Bureau statistics available are those taken at Estherville, Iowa, 7 miles east of the county. According to these records the mean annual rainfall is 31.89 inches, ranging from 17.95 in the driest year (1895) to 37.67 inches in the wettest year (1909). Rainfall is generally light in March and April, heaviest during May and June, and well distributed during the remainder of the growing season to September. Winter is the driest season of the year. Snow seldom covers the ground during the whole of this season. Protracted dry spells during the growing season are uncommon, and rains are seldom accompanied by damaging winds or hail.

The mean monthly temperatures range from 12.7° F. in January to 70.7° F. in July, and the extreme temperatures range from —36° in January to 105° F. in July. Periods of excessive heat or cold are seldom of long duration.

The average growing season is from May 10 to September 27, a period of 140 days between killing frosts. The latest spring frost on record occurred on May 31, and the earliest fall frost, September

13. The average grazing season starts 15 days earlier in the spring and lasts 15 days later in the fall than the growing season.

The table below is compiled from the records of the Weather Bureau station at Estherville:

Normal monthly, seasonal, and annual temperature and precipitation at Estherville, Emmet County.

[Elevation, 1,298 feet.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1909).
	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
December	19.9	56	−28	0.81	T.	1.55
January	12.7	58	−36	.61	0.50	1.05
February	15.0	58	−31	.78	.10	1.99
Winter	15.9	58	−36	2.20	.60	4.59
March	28.6	73	−19	1.29	.25	.65
April	45.1	85	12	2.49	2.54	2.73
May	57.6	93	23	5.07	1.67	6.47
Spring	43.8	93	−19	8.85	4.46	9.85
June	66.3	101	35	4.71	2.19	7.01
July	70.7	105	44	4.53	1.51	4.75
August	69.1	97	38	4.10	3.16	1.85
Summer	68.7	105	35	13.34	6.86	13.61
September	60.1	96	23	3.69	4.72	4.69
October	47.8	88	7	2.42	.43	1.47
November	31.5	75	−5	1.39	.88	3.46
Fall	46.5	96	−5	7.50	6.03	9.62
Year	43.7	105	−36	31.89	17.95	37.67

AGRICULTURE.

The earliest settlements were in the forests surrounding the lakes, because the abundance of game and fuel in these sections was important in the livelihood of these pioneers. Even as late as the years following the Civil War hunting and fur trading were the chief interests of the settlers; farming was neglected, with the exception of a little stock raising, and the prairies remained unsettled. The first prairie farming settlement was started in 1868. The fuel problem here was solved by using prairie hay. Wheat was the most important crop. In 1869 the Okoboji Mill, still a landmark, was built on the outlet of the large lakes south of the present site of Milford. A period of prosperity followed, and settlers came in great numbers; but in the period from 1873 to 1877 the grasshopper invasion became so severe as to cause destitution and the abandonment of land.[1] This accounts in part for the slow settlement between 1870 to 1880 as compared with the later 10-year intervals.

[1] History of Dickinson County. By R. A. Smith.

In 1880, according to the census, 16.9 per cent of the county was in farms, which had an average size of 149 acres. Owners operated 78.4 per cent of the farms and tenants the remainder. Hay, corn, wheat, and oats occupied the largest acreages, and minor acreages were in barley, rye, flax, buckwheat, sorghum, potatoes, beans, and Canada peas. Too continuous cropping of wheat, since it first gained favor in 1867, had resulted in decreasing yields and acreages.

In 1890, 42.2 per cent of the county was in farms, with an increase in the size of farms and also in the improved acreage. Hay was cut from more than one-fourth of the farm land. Corn and oats were next in acreage. Wheat showed a marked decrease in relative importance and occupied a smaller acreage than either flax or barley. Flax was commonly used as a new-ground crop, and with the greater amount of such lands in farms its acreage increased. Barley became a substitute for wheat and increased in acreage. Among the minor crops were rye, buckwheat, and potatoes. With about half of the county's farmers of but little more than five years' residence, farms were not well stocked as yet; nevertheless, after the decline of wheat farming the trend was toward live stock, corn, hay, and oats as the farmers' mainstays.

In 1900 over 92 per cent of the county was included in 995 farms, of an average size of 223.1 acres, of which about 200 acres, or 89.6 per cent, was classed as improved farm land. This shows improvement and a degree of intensification accompanying farm expansion. The chief crops in 1899, in the order of their acreage, were corn, hay, oats, wheat, and barley. The greatest increase was that of wheat. Large tracts of comparatively new land account for the revival of wheat cropping. For the first time corn exceeded hay in acreage. The greater part of the hay grown was wild hay, but tame grasses were being grown to a greater extent and occupied 44 per cent of the hay acreage. Of the minor crops, flax and potatoes were the most important, and buckwheat and rye occupied only small acreages. Orchards and small fruits received more attention. Cattle and hog fattening, dairying, and poultry raising were becoming prominent, and in 1899 live-stock products were marketed in appreciable quantities.

In 1910, 86.5 per cent of the county was reported in farms averaging 211.5 acres in size. This constituted a slight decrease in farm acreage. The greater part of this decrease is accounted for by the fact that considerable areas of the more poorly drained land settled 10 years earlier had been abandoned without improvement. More efficient cooperative and county drainage projects were just being started. The total area of improved land remained about the same during the decade, but the advanced state of improvement is indicated by the doubling of the farm-land values. Tenancy continued to increase, and 50.2 per cent of the farms were operated by tenants in 1910.

The trend toward more general farming practices noted in 1890, with the decline of wheat growing, practically displaced specialized farming during the period from 1900 to 1910. In 1909 the acreage of corn was 22 per cent of the farm acreage and the acreage of oats was 18.5 per cent and about equal to the acreage of hay. The barley acreage had decreased to 1.5 per cent of the farm land, and wheat

and flax were minor crops. Hay occupied about the same relative acreage throughout the period, but the cultivated-grass acreage increased, with a corresponding decrease in wild-hay land.

The cereal, grain, seed, and hay crops produced in 1909 were valued at $1,320,766. The combined value of the animals sold or slaughtered and of the dairy products, poultry, eggs, and wool produced in 1909 was reported as $970,843, which is double the value reported for 1899. Crops were marketed in quantities, while 10 years earlier most of the crops raised were utilized within the county. Sheep raising and wool production were at their height in 1910.

The most notable changes since 1910 have been drainage improvement, increase in cultivable lands, increase in acreage of corn and oats, and increasing activity in live-stock industries. The trend has been toward farms of smaller size. Tenancy has continued to increase, 60 per cent of the farms being operated by tenants in 1920.

In the improvement of farm lands drainage has received first attention, and rapid strides have been made in that work. According to the 1910 census, 20,221 acres in the county were swampy or subject to overflow. In 1920 only 1,833 acres remained in that condition, showing a decrease of 90.9 per cent as a result of drainage improvements. In 1920, 2,852 acres were reported drained by open ditches, 18,967 acres by tile, and 78,498 acres by tile and open ditches combined; a total improved acreage of 100,317 acres, or about 41 per cent of the county's land area.

At the present time general farming prevails. Corn, oats, and hay are the principal crops. Wheat, barley, flax, potatoes, rye, and buckwheat are secondary crops, ranking in importance about as named. Hog raising is the most extensively practiced live-stock industry, with the raising and fattening of beef cattle, dairying, and sheep raising ranking in the order named. Dairying is more commonly engaged in than sheep raising; the latter, however, where practiced, is on a larger scale. Dairying, a common subordinate interest, receives relatively more attention in the sections near local markets. True live-stock farming is not practiced extensively, and is engaged in chiefly by resident farm operators. While statistics are lacking, the value of live-stock products marketed in 1920 probably bears about the same relation to the value of crops as in 1910.

Corn is the leading cash crop of the county. The 1920 census reports a corn acreage of 54,496 acres, or 26.3 per cent of the farm lands in 1919, with yields averaging 40.6 bushels per acre and a total of 2,214,480 bushels, the largest production on record. Larger quantities of corn are marketed than of any other crop, yet probably half of that produced is fed to stock. Local elevators, through which the market crop is handled, ship mainly to Chicago. Mixed home-grown varieties of both yellow and white corn are grown principally. Of the pure strains, Silver King, a white dent corn, is popular and is said to be the best adapted to local conditions and the most productive. A few farmers are engaged in the production of seed corn for the market.

According to the census the acreage of oats in 1919 was 48,184 acres, or 23 per cent of the total farm acreage, with a total production of 1,622,162 bushels and an average yield per acre of 33.7 bushels. The greatest annual production on record was 1,841,061

bushels, reported in the State census of 1918. Oats rank second to corn as a cash crop, but a relatively greater part of the crop is fed. The chief advantages of the oat crop are its usefulness as feed and its adaptability in systems of crop rotation as a follow crop for corn. Both early and late varieties are grown. Green Russian is the principal late variety, and Kherson, Albion (Iowa No. 103), Richland (Iowa No. 105), and Early Champion are the main early varieties. Except in a few cases where oats are produced for market as seed, mixed home-grown seed is usually sown. Chicago is the principal market for the oats sold through the local elevators.

Hay and forage crops rank third in acreage, occupying a total acreage of 30,273 acres, or 14.5 per cent of the farm lands in 1919, with a production of 54,155 tons. Wild hay was cut from 11,142 acres, yielding 13,088 tons, and tame grasses were grown on 14,599 acres, producing 19,462 tons of hay. The rest of the total consists mainly of silage crops and corn cut for forage. Of the cultivated grasses, timothy, and timothy and clover mixed, are by far the most important. Clover alone, millet, alfalfa, and sweet clover are sown to a small extent, ranking in about the order named. Clover and alfalfa are growing in favor as their soil-improving qualities become more widely recognized. Millet is grown chiefly as a catch crop. About 700 acres each of timothy and clover are annually harvested for seed, timothy ordinarily yielding 4 bushels per acre and clover about 6 bushels per acre.

By far the greater part of the hay crop is fed. At present but little is marketed, and most of that is sold locally. Where extensive feeding operations are carried on, it is sometimes necessary to ship in considerable quantities of hay.

About 1,000 acres of corn are cut annually for silage, ordinarily yielding 8 to 12 tons per acre. Occasionally soy beans are grown between the corn rows and included in the silage. Frequently rape is sown in corn and oats, occasionally alone, principally as forage for sheep and hogs. In the maintenance of permanent pastures timothy, bluegrass, and alsike clover are most commonly used.

Wheat growing received an impetus during the late war period, and 3,049 acres were in wheat in 1919 as compared with 938 acres in 1909. The acreage seems to be on the decline, however. Spring varieties are grown almost entirely, only 103 acres of winter wheat being reported for 1920. The Marquis variety is most extensively grown. Although some report the winter varieties as yielding higher, the risk of winterkilling is usually considered too great. The flour mills of northwestern Iowa usually obtain the bulk of the market crop.

Barley decreased in acreage from 3,126 acres in 1909 to 1,619 acres in 1919. The yields in 1919 averaged between 20 and 30 bushels per acre. Barley is chiefly grown as a substitute for oats in crop rotations and is utilized as a cash crop, although small quantities are fed to young growing stock.

According to the census of 1920 there were only 383 acres in flax in 1919. Flax is sown only on newly broken sod land, usually of the poorer drained virgin soils, and is seldom grown for two successive years. Potatoes are generally grown on a small scale for home use, and to a very small extent for market. They occupied 356 acres in 1919, with an average yield of 90 bushels. Rye, buckwheat, emmer,

and sorgo are minor crops, occupying altogether less than 250 acres in the county.

Orcharding is much neglected on the average farm. Apples are the most extensively grown fruit, 2,534 bushels being reported as the 1919 harvest. Peaches, cherries, plums, and grapes also are produced. Small fruits, such as raspberries, blackberries, and strawberries, are occasionally grown. The market at Milford reported handling during 1919 from 6,000 to 8,000 quarts of berries, produced within a radius of 7 or 8 miles of that town. Sweet corn and other garden vegetables and truck crops are grown, usually only for the farm table. In the vicinity of the large lakes, however, trucking is engaged in on a small scale, the supply of these products being inadequate for the demand during the vacation season. Selling directly from house to house is the usual practice.

Of the various branches of the live-stock industry, hog raising is of first importance, followed in order by beef-cattle production, dairying, horse and mule production, and sheep raising.

Hogs are raised on practically every farm. Owing to the quick returns, hogs can be handled as well by the one-year tenant farmer as by the resident farm owner, although usually not on as large a scale. A total of 43,446 hogs, of which 10,579 were brood sows, is reported in the 1920 census, making an average of 9 to 10 brood sows and a total herd of 40 per farm. Most of the hogs raised are of mixed breeds, though the number of purebred animals is increasing. The Duroc-Jersey, big-type Poland-China, and Chester White are the most popular breeds. There are a few herds of Hampshire and one herd of Berkshire animals. Hog cholera occasions some loss, 1,466 animals dying of this disease in 1919. The supply of hogs far exceeds the local demands, and direct shipments are made to Chicago, Omaha, and St. Paul.

In 1919, according to the 1920 census, the cattle of the county numbered 28,586, of which 10,401 are classed as dairy cattle and 18,105 as beef cattle. It is estimated that about 7,000 to 7,500 of these are strictly dairy stock, from 5,000 to 6,000 are feeder stock, and the rest are raised chiefly as dual-purpose stock. Most of the beef cattle marketed are home raised. It is the common practice to raise the cattle on pasturage and supplementary roughage, and to finish them at the end of the fattening period on roughage and concentrates. Feeder cattle are bought principally from Sioux City, but some from Omaha and St. Paul, and are sold on the Chicago market as fat stock. The feeding period usually lasts from late summer to early spring. Cattle of mixed breeds predominate, but the purebreds are receiving more and more attention. The Shorthorn seems the most popular breed, followed by the Hereford and the Angus.

The dairy industry is centered chiefly near local market points and is expanding. It is the common practice to separate the milk, feed the skimmed milk to hogs, and market the cream at local creameries. The local creameries report that their patrons milk 8 to 10 cows on the average, a few herds numbering 25 to 30 head. A compilation of estimates and actual figures furnished by the local creameries shows that 536,500 pounds of cream were produced and marketed by county patrons during 1920. A small part of the

butter manufactured is sold to patrons and in near-by markets, but the greater part is shipped out of the State. The majority of the milk cows kept are of mixed breed and are handled as dual-purpose stock. Most of the purebred herds consist of Holstein cattle. The next in popularity is the Guernsey. Dairying, however, is engaged in chiefly as a side line. Cows are pastured during the grazing season and supplied with a little additional feed and are wintered on roughage and concentrates.

The production of horses and mules is general. The 1920 census reported 8,367 horses and 342 mules, representing an average of 8 head per farm. Within the county were 10 registered stallions and 4 jacks. Work horses are generally of good draft type, although little attention is given to purebreds. Usually there is a small surplus for market. The purebred horses of the county include animals of the Percheron, Shire, and Clydesdale breeds.

The sheep industry of the county consists of the production of wool and fat sheep and the fattening of feeder lambs. In 1920 sheep numbered 4,568, nearly half of which were feeder stock kept for short-time fattening periods. In 1920, 19,964 pounds of wool were reported as marketed from native sheep. Feeder lambs are obtained in carload lots, principally from Omaha and St. Paul, and marketed in Chicago after an average fattening period of 100 days. The feeding period usually lasts from early September to the middle or last of December. Sheep raising is carried on principally in the more rolling pasture sections in proximity to the main streams and lakes of the county.

Some poultry is raised on most of the farms of the county. According to the 1920 census, chickens numbered 132,120, or an average of about 125 per farm. According to official estimates 395,700 dozen eggs are marketed annually at the local produce stations. Five of the nine local markets of the county report a total of 130,112 pounds of poultry received during 1919. An annual market production of 275,000 pounds is a conservative estimate for the county.

There are no soil types in the county that require special cropping practices, and soil influences and crop adaptations are recognized only in a general way. The heavy upland soils are known to produce a more rank growth and later maturing crops than the lighter soils. The heavy soils are recognized as better for corn than for small grains, since with small grains the tendency is toward stalk growth rather than grain production. On the heavier terrace and first-bottom soils, where drainage is commonly poorer than on the heavier upland soils, this adaptation holds true to an even greater extent. Most of the first-bottom soils are too poorly drained for crop production and are generally kept in permanent pasture. The more rolling uplands are also kept in pasture. Flax is usually grown on newly broken lands, chiefly those being reclaimed from poor drainage conditions. The sandy loam and light loam soils are chosen for alfalfa.

While long-continued cropping to any one crop is not usually practiced, definite systems of crop rotation are generally used only by the more progressive farmers. Where practiced, the rotation most generally followed is corn two years, followed by oats, with

a seeding of clover and timothy. Corn one year, wheat or barley in place of oats, clover or timothy alone in place of timothy and clover mixed, are variations from the rotation most commonly employed. When grown, alfalfa usually follows small grains and is left for five to eight years.

Land intended for corn is plowed, either fall or spring—fall plowing is considered best—and is then disked and harrowed until in shape for planting. The planting season is from May 1 to May 20, later plantings being made in occasional cases of wire-worm infestation. Replantings are sometimes made necessary by unseasonable weather, and when postponed as late as June 10 or 15, the crop is commonly used for fodder or silage. Millet and other catch crops are sometimes grown in such cases. Corn is cultivated four or five times when possible. Quack grass, smartweed, foxtail, and buttonweeds give the most trouble; thistles, ironweed, and cocklebur are less troublesome. Corn harvesting is in progress from October 15 to early winter. The selection of seed corn in the field before frost is a practice that is gaining in favor. Usually a part of the field is left for hogging down. Silage and fodder harvesting usually start between September 15 and October 1. After harvest the corn fields are utilized for fall and winter pasturage. Spring plowing follows for either corn or small grain.

In preparing land for small grains, disking and harrowing a number of times is essential to give the best possible seed bed. The seed is generally sown broadcast; less frequently drilled. Small grains are used as a nurse crop for clover and timothy. The grasses usually provide one cutting after the grain is harvested, and in favorable years light pasturage in addition, but more often pasturage is not available until the following spring. Sod land is plowed for corn. Oats are sometimes sown alone and followed by winter wheat. Alfalfa sown in spring usually follows corn; when sown in fall it follows one of the small grains. Rape is sometimes sown in corn at the last cultivation for sheep forage, or in oats or alone for late summer and early fall forage for both sheep and hogs.

The farms of the county are provided with horse barns and haymows, cattle barns, hog houses, corncribs, granaries, implement sheds, chicken houses, and some other additional buildings. About 14 per cent of the farmhouses are reported of modern type. Corncribs, granaries, and haymows are commonly inadequate in seasons of large production.

All farms have excellent water supply and are equipped with windmills or engine pumps for watering stock. In 1920, 95 silos were reported, of which 50 per cent were of concrete, 46 per cent of brick and tile, 4 per cent of wooden-stave construction. There were 94 tractors on farms. Three-bottom and four-bottom plows are used with tractor power and two to three bottoms with horsepower, except on the heavy soils, where more draft power per bottom is required. The implements in general use are corn planters, gang and sulky plows, four-section harrows, two-section disks, one-row and two-row cultivators—both shovel and surface types—movable or stationary grain elevators, grain drills and broadcasters, self-binders, mowing machines, hayrakes, manure spreaders, dump and side-delivery and sweep rakes, hay stackers, haymow track, mowing

forks or slings, fanning mills, hand separators, and minor implements. Tractors, hay loaders, corn binders, corn pickers, silage cutters, and stationary gas engines are less commonly included with the equipment. Threshing machines and separators sometimes are owned cooperatively. Barbed-wire and woven-wire fences inclose all fields and are usually kept in good repair.

The manure produced is well cared for, as a rule, and applied to the land, usually on hay or small-grain stubble land intended for corn. Commercial fertilizers are used only in a few special cases. Lime has been used very little, and then chiefly in preparation for alfalfa seeding. Five carloads of lime were used during the four-year period from 1916 to 1920.[2] Green manuring is rarely practiced. Red clover grown alone is sometimes used for that purpose.

The majority of the farms may be termed family-size farms. Extra help is most in demand during grain harvest and corn picking. Efficient labor is often hard to find. Labor of the best class can usually only be obtained upon the full-year basis. The State census of 1918 reported the average summer wage as $51 a month with board and the winter wage as $44 a month with board. During the 1920 grain harvest the hands were paid from $2.50 to $3.50 a day, and corn pickers in the same year received 6 to 7 cents a bushel.[3]

The 1920 census reported 1,043 farms in the county, with an average size of about 200 acres. The average range is from 160 to 240 acres. Near towns and in certain parts of the region near the larger lakes the farms are of smaller size, ranging from 40 to 100 acres.

Tenancy has been on the increase, owing to the prevalence of absentee landowners. In 1920, 612 farms were operated by tenants and 431 farms by owners and managers. During the period from 1910 to 1920 tenancy increased 22 per cent. Leases generally provide for share rent for grain lands and cash rent for pasture and hay lands. Share rents vary between two-fifths and four-fifths of the products, depending upon the obligations of the tenant and owner. Cash rents ordinarily range from $8 to $12 an acre.

Farm-land values in 1920 were in a period of readjustment succeeding the land boom of 1919. Therefore it is difficult to arrive at fair valuations based on actual cash sales. Market facilities, state of improvement, topography of land, and character of soil all are factors giving land values a wide range—from $100 to $350 an acre.[4]

SOILS.[5]

Dickinson County, Iowa, lies in the prairie region of the United States, where the influences of topography, moisture supply, and temperature favor a heavy grass vegetation. It is not necessary to discuss in this report the various theories concerning the existence

[2] Statement of the county agricultural agent.

[3] These wages are higher than wages paid in periods of normal price levels.

[4] Rents and land prices have declined somewhat since the time of making this survey (1920).

[5] Dickinson County adjoins Clay County on the south. The soil maps of the two counties do not agree in places along the boundaries. As a result of changes in correlation necessitated by a fuller knowledge of the soils of the State, the Carrington loam, as mapped in Clay County, has in this area been mapped as Clarion loam, and soils of the Shelby series have been included in the Dickinson series. Also, on account of the small size of the areas of Carrington fine sandy loam along the border, they have been combined in this area with the Carrington loam.

of prairies; it is sufficient to state that conditions were so unfavorable to the spread of forest trees that when this county was first settled hardly an acre of heavy forest had established itself upon the upland.

The soils of the area, therefore, without exception, show those characteristics which indicate that they developed under the influence of a prairie vegetation and that an optimum condition of moisture prevailed during the operation of the soil-forming processes. The most striking characteristic of these soils is the dark color, imparted to them by the large quantities of black organic matter which has accumulated in the surface layer. This organic part of the soil, derived principally from decaying grass roots, is in the form of finely divided carbonaceous material intimately mixed with the mineral constitutents. The quantity of this organic matter and the depth to which it has affected the color and the physical structure of the soil in any given locality have been determined very largely by the average drainage conditions. On flats and sloughs the black organic matter extends to depths of 15 to 24 inches, but on the well-drained ridges it does not affect the soil below 8 or 10 inches. Muck represents extreme conditions with respect to the accumulation of organic matter.

On the flat and undulating areas the average moisture content was formerly high and the ground water level was near the surface. In many places water stood over the surface for days after heavy rains. Consequently there was a large accumulation of organic matter in the surface and the upper subsoil, while the lower subsoil almost escaped leaching and oxidation, resulting in the formation of a deep black soil over a light-colored or mottled calcareous subsoil. These are the characteristic features of the soils which have been classed with the Webster series on the poorly drained areas of the upland. Similar conditions acting upon the alluvium of the sloughs and depressions and upon the poorly drained flood plains and terraces have produced the soils classed with the Lamoure and the Fargo series.

Where the topography is more rolling and better drainage conditions have prevailed, there has been a more vigorous movement of the soil water. As a result, more thorough oxidation and leaching have taken place and the carbonates have been largely removed to depths of 3 feet or more. Soils developed under these conditions have dark-brown surface soils and uniform brown or yellowish-brown subsoils. This group of soils is represented by the Carrington and the Dickinson series in the upland and by the O'Neill series of the terraces.

Over a large part of the county the conditions were rather favorable to leaching and oxidation except in the deep subsoils, but these processes have not advanced as far as in the Carrington group. The surface soils over such areas are dark brown to almost black. The upper subsoils have a smooth brown color and the lime content is not high. These upper horizons do not differ essentially from the corresponding horizons of the Carrington group. The lower subsoil, however, beginning at an average depth of 30 inches, has a brown or grayish-brown color and normally contains an important percentage of lime carbonate. This lower subsoil is the parent material little altered by leaching and oxidation. The lime is a constituent of the parent rock, but may in places be localized. To this general

group belong the Clarion and the Pierce series of the upland and the Sioux series of the gravel terraces.

The soils of each of the groups mentioned above are differentiated into series on the basis of differences in the color, structure, and minor details of the soil profile and on the basis of the source, character, and processes of accumulation of the material from which the soils have been developed.

The parent materials of the soils of Dickinson County were of glacial deposition and formed a part of the Wisconsin drift sheet. This unstratified drift deposit has a variable depth, which is in places difficult to determine. The underlying beds of blue clay belonging to the older Kansan drift are encountered at a depth of 30 feet in the western part of the county.[6] In many places a layer of sand and gravel tops this older drift and an excellent supply of water is obtainable from its depths. The surface drift consists predominantly of clay and silt. The sand and gravel intermixed occur in greater abundance throughout the soils of the morainic sections and outwash terraces and in smaller quantities in the soils of the level drift plains. Rocks and bowlders are likewise most abundant within the moraine. Granite and quartzite are the chief rock constituents, with porphyry, gneiss, syenite, greenstone, trap, and limestone in smaller proportions.

The materials of glacial deposition have been acted upon by the agencies of weathering and erosion to form the various soils of the area. As a result of leaching, oxidation, the translocation of clay particles, the addition of organic matter, and other processes the raw glacial drift of the upland has been brought to its present condition as a productive soil. In this county there have been developed upon the drift five series of soils, which owe their characteristics in part to the composition of the parent material, but probably more to the varying intensity with which the great soil-forming processes have acted. The drift material, removed and redeposited by the streams and acted upon by the same soil processes, has formed the alluvial soils of the county.

The water-transported soils of the county consist of those on glacial-outwash gravel terraces, on lower elevated terraces with heavy subsoils, and on the first bottoms or flood plains. The outwash gravel terraces are the most extensive, occupying a large continuous area along the Little Sioux River in Okoboji Township. The most extensive of these terraces occupy positions high above the stream levels. In places, however, these terraces are well defined at several different levels, the lowest 15 feet and the highest 60 to 70 feet above the channel. The soil materials uniformly consist of a loam surface deposit over stratified sand and gravel. This sand and gravel has been deposited by swiftly moving waters issuing from the melting ice sheet to the north. The loam surface is of more recent formation, possibly alluvium or loess, or a combination of the two. Lying within a region of highly calcareous drift, the absence of lime in the greater part of these terraces is notable. In their case leaching has progressed so rapidly that now calcareous material is not generally found above

[6] The statements in this paragraph relative to geology are based on the Annual Report of the Iowa Geological Survey, 1899. Geology of Osceola and Dickinson Counties.

a depth of 5 to 10 feet. The heavy, subsoil terraces range in elevation from 5 to 15 feet above water levels or first bottoms, and in some places they are occasionally flooded during stages of exceptionally high water in the streams. The content of organic matter in the surface material of these terraces is high. The subsoils are strongly calcareous and are dark to light gray in color and mottled.

The first bottoms of streams are predominantly of fine-textured materials carried from the adjacent glacial soils. In the lower course of the Little Sioux River in the county the bottom soils vary more in texture and are not so heavy. Likewise the materials are low in lime in comparison with the first-bottom materials elsewhere, which in places are calcareous even in the surface or at least the subsurface layers. A rank growth of slough grass has occupied most of these soils, and a high accumulation of organic matter has resulted.

In the small basins and sluggish drainage ways of the uplands the surface soils have been modified by materials from the adjacent slopes. These soils are poorly drained, the traversing drainage ways often being only stagnant sloughs. Even the best drained areas usually remain saturated for considerable lengths of time after rains. The soils of former lake beds of exceedingly poor drainage have been classed as alluvial, although they may not be entirely composed of transported materials. The soil material left by the glacier in these depressions has since received two important additions through the incorporation of organic matter and the deposition of materials transported from the adjacent slopes.

There follow brief descriptions of the various series as standardized not only for this county but for the general region of their occurrence. These series are divided into types upon the basis of the textures of the surface soils.

The Clarion series comprises types with dark-brown to black surface soils and a subsoil of grayish-yellow silty clay loam to silty clay, highly calcareous. Sand and gravel intermixed are present only in small quantities as a rule. The Clarion loam, fine sandy loam, and silt loam are mapped in Dickinson County.

The Carrington series consists of types with dark-brown to black surface soils and a subsoil of yellow or brownish-yellow silty clay. Neither soil nor subsoil is highly calcareous. In the present survey sand, gravel, and bowlders are of more common and extensive occurrence than in the Clarion soils. The Carrington loam and silt loam are mapped.

The Pierce series comprises types with surface soils that are dark brown in color. The subsoil is loose sand and gravel or light sandy gravelly clay loam, calcareous to a moderate degree. The fine sandy loam and the loam are mapped.

The surface soils of types of the Dickinson series are dark brown to almost black. They are underlain by brown to yellowish-brown materials which are heavier in texture, as a rule, than the surface soils, having a sandy loam or sandy clay texture. Below depths ranging from 18 to 30 inches a brown or yellowish-brown loose sandy loam is encountered. The lower subsoil is loose, porous, and somewhat droughty. Neither soil nor subsoil is highly calcareous. The

series is developed by weathering from a sandy drift. It is represented in this county by the fine sandy loam and the loam.

The types of the O'Neill series have dark-brown to black surface soils and a subsoil of stratified sand and gravel or very gravelly clay loam with a low lime content. These soils occupy outwash terraces, generally of the higher elevations. The fine sandy loam and the loam occur in this county.

The Sioux series consists of soils differing essentially from the O'Neill in their higher content of lime. As this series occurs in this county it is more generally found on the outwash terraces of lowest elevation. Only the loam member of the series is mapped.

The Fargo series comprises all the heavy-subsoil terraces of the county. The surface soils are black, and the subsoil is a mottled dark-brown to light-gray or brownish-gray, highly calcareous silty clay to clay. Natural drainage is poorly developed. The Fargo series is represented by the silt loam and silty clay loam.

The surface soils of types of the Lamoure series are almost black and are underlain by a mottled dark-gray to light-gray or brownish-gray heavy silty clay loam to silty clay. The subsoil is calcareous and the surface soils in places effervesce with acid. The series is developed in the first bottoms and is represented in this county by the silty clay loam.

The Wabash series consists of types with black surface soils underlain by a slightly mottled dark-brown to black silty clay loam to silty clay with a low lime content. The Wabash soils differ from the Lamoure soils mainly in their lower percentages of lime in both soil and subsoil. The Wabash silt loam is mapped in the first bottoms of streams in this county.

Muck consists of the partially decomposed organic remains of former lake-bed plants incorporated with varying amounts of silt and sand. This material, black in color, extends to depths of 16 to 18 inches, as a rule, and is underlain by dark brownish gray to light-gray, highly calcareous silty clay loam to silty clay.

In the following pages of this report each soil type is described separately and more in detail with respect to its characteristics and agricultural development. The distribution of the soil types is shown on the accompanying soil map, and their actual and relative extent are given in the table below.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clarion loam	78,144	40.4	Sioux loam	2,368	1.0
Rolling phase	18,944		Carrington silt loam	2,112	.9
Lamoure silty clay loam	38,016	15.8	Clarion fine sandy loam	2,112	.9
Webster silt loam	25,408	10.5	Dickinson loam	1,600	.7
Clarion silt loam	17,792	7.4	Fargo silt loam	1,088	.5
Carrington loam	13,888	5.8	Dickinson fine sandy loam	1,024	.4
Pierce fine sandy loam	10,112	4.2	Wabash silt loam	832	.3
O'Neill loam	8,640	3.6	O'Neill fine sandy loam	768	.3
Muck	7,168	3.0	Fargo silty clay loam	704	.2
Pierce loam	5,888	2.4			
Webster silty clay loam	4,032	1.7	Total	240,640	

CLARION FINE SANDY LOAM.

The Clarion fine sandy loam is a brown to dark-brown fine sandy loam with a depth of 10 inches, passing into a lighter brown to yellowish-brown, heavy, compact silt loam to silty clay loam, which at 18 inches grades into a light-yellow or grayish-brown, friable silty clay loam, semicompact in structure and retentive of moisture. Usually at a depth of 24 to 28 inches the gray color of the weathered limestone material becomes more prominent and the subsoil is highly calcareous. With increasing depth the glacial clay, sand, and gravel becomes more abundant, sufficient in places to impart a heavy sandy clay loam texture, with a structure much less compact and retentive of moisture than is typical. Bowlders are exposed on the surface and encountered in the soil here and there.

The type occurs most extensively between the Little Sioux River and West Okoboji Lake, in Lakeville Township, and east of Swan Lake, in Superior Township. The latter area represents the type in its most rolling topography. Here drainage ways irregularly dissect the area into ridges with narrow crests and with slopes in places steep and eroded. Such ridges are common on this type where the individual areas are small and occur within sections of morainic topography. Some of these areas resemble the isolated kames of the Pierce soils, but in such cases bowlder clay constitutes the glacial deposit in place of gravel heaped in kame construction. Where morainic features are less pronounced and the areas of the type are larger, the topography is gently rolling to rolling. Such areas are found in section 15, Milford Township, and section 21, Center Grove Township. The larger area in Lakeville Township is in part of the more irregular, hillocky topography. Here as elsewhere the Clarion fine sandy loam is closely associated with the rolling phase of the Clarion loam.

The natural drainage of the type is well developed, being better than that of the Clarion loam and not as excessive as that of the Pierce soils.

The type has a total area of about 3 square miles. Practically all of it is utilized for agriculture, about 50 to 60 per cent being in grain crops and the remainder in hay and pasture. A very small part supports trees, which are remnants of an original forest, but even these forest areas are utilized for light pasturage. The type, however, is mainly a prairie soil. Corn is the main crop, but small grains are grown to a greater extent than on the heavier upland soils. The hay and pasture lands of this soil produce a large quantity of feed. The fattening of hogs, cattle, and sheep is carried on to a considerable extent. Dairying is a minor industry on the type, except on a few farms near local markets. The crop yields obtained are lower than those on the Clarion loam, but higher than those on the Pierce soils.

Farmers recognize that the organic-matter content of this soil is low and give it heavier applications of manure. Also, because of the loose structure of the surface soil, the steeper slopes are nearly always kept in permanent pastures to prevent damage by erosion.

Land of this type is valued at $100 to $250 an acre, depending upon the state of improvement, topography, and convenience of markets.

Heavy manuring, a legume in the rotation, and green manuring would be beneficial to this soil. On some of the erosional slopes a better pasture sod or a cover crop is needed.

The table below gives the results of mechanical analyses of samples of the soil and subsoil of the Clarion fine sandy loam:

Mechanical analyses of Clarion fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
334003	Soil, 0 to 10 inches	6.6	7.3	6.2	25.5	14.2	29.4	10.8
334004	Subsoil, 10 to 36 inches	3.6	7.5	4.9	20.2	16.1	31.0	16.8

CLARION LOAM.

The surface soil of the Clarion loam is a dark-brown to black mellow loam, extending usually to a depth of 12 to 14 inches, underlain by a subsurface soil of light-brown to brown, moderately friable, heavy silt loam, extending to a depth of 16 to 18 inches. The subsoil is a light-brown to yellow grayish brown, semiplastic silty clay loam. The subsoil, and in places the subsurface soil, is moderately to highly calcareous, and limestone concretions and segregations of light-gray calcareous material occur in the lower subsoil. Sand and pebbles are commonly present in small quantities in the soil, and occasional bowlders are exposed on the surface, particularly on the more rolling lands.

Areas that have a more rolling topography, a lighter colored surface soil, and a higher content of sand, pebbles, and bowlders than typical, are mapped as a rolling phase of the Clarion loam, but the boundaries between the type and the phase are often arbitrary.

The texture of the surface soil is more variable within the morainic regions than in the drift plains, ranging in the former from a light sandy loam to a loam, and in the latter from a light loam to a heavy loam, or in places a silt loam. However, there are extensive areas in the morainic sections with a surface soil as uniformly a heavy loam in texture and as free from sand, pebbles, and bowlders as is characteristic of the drift-plain areas; and, on the other hand, the lighter and more variable surface soil occurs to some extent within the drift plains. Another variation consists of the presence of thin layers of sand and gravel, either in the subsurface or deep subsoil. Such areas are found both in drift plain and moraine sections, though more extensively in the latter. The Clarion loam lies adjacent to many other soil types, and the boundaries in places are more or less arbitrary. Within the areas as mapped are spotted occurrences of upland soils, too small to show, principally of the Clarion fine sandy loam and silt loam, the rolling phase of the Clarion loam, and the Carrington soils.

The Clarion loam is the most important upland soil of the county. As the areas approach the large streams and lakes and the morainic region of the county, this type gives way in extensiveness to the rolling phase of the Clarion loam and the Carrington and Pierce

soils. As the areas approach the level drift plains, the heavier Clarion silt loam and Webster silt loam become the predominant types. The Clarion loam is most typically developed in the northern parts of Richland and Excelsior Townships.

In general a gently rolling topography prevails. The most rolling relief is in the morainic regions. Areas in Superior Township and eastern Diamond Lake Township contain ridges with rolling slopes and narrow crests and represent the Clarion loam in its most rolling relief. Long slopes of moderate degree and broad-crested elevations are the most prevalent over the areas as a whole.

The natural surface drainage is well developed, except on the broadest divides and longest gentle slopes. Internal drainage is excessive in but few places; it is more likely to be inadequate and to need improvement by tile drains. Streams and drainage ways are generally sluggish, but where they have regular courses they carry the run-off efficiently. In areas of the most rolling topography many of these drainage ways are irregular in direction, with a sluggish flow arrested by small barricades in the uneven levels of their beds. Such a condition transforms these drains into nothing more than a network of sloughs. In the lower lying areas of most gently rolling topography the watershed of each upland draw is larger and the natural run-off is too slow to prevent saturation and an almost permanently waterlogged condition.

Being the most extensive soil type of the county, with practically all of it put to agricultural use, the Clarion loam ranks first in importance. Originally this type was covered with prairie grasses, with small strips of timber in the vicinity of the main lakes and streams, of which only occasional remnants are left. At present the more rolling lands, although cultivable, are utilized mainly for pasture.

All the common crops of the county are grown on this type. Corn ranks first, tame hay second, and oats a close third, followed by wheat and barley. The hay produced is fed to stock, with the exception of small quantities marketed locally. Clover and timothy mixed and timothy alone are most commonly grown. Clover alone is grown on a small acreage and alfalfa in patches. Clover and alfalfa yield well and their acreage is increasing. The raising and feeding of live stock is not on as large a scale as on the rolling phase and on heavier upland types; also a smaller proportion of the crops is fed. Hog raising is the leading live-stock industry; the raising and fattening of cattle ranks second. Near local markets dairying is receiving more attention, but in general is only a subordinate interest. The production of wool and the fattening of western and home-raised lambs receives considerable attention on some farms.

Crop yields on this type range a little higher than the average for the county. Corn ordinarily yields 35 to 45 bushels per acre, and occasional yields of 70 bushels are reported. A small acreage is cut for fodder and ensilage, yielding ordinarily 10 to 12 tons per acre. Oats yield 30 to 35 bushels per acre; wheat, 12 to 15 bushels; barley, 20 to 30 bushels; clover and timothy, mixed, 1½ to 2½ tons; timothy alone, 1½ tons; clover alone, 2 to 2½ tons; and alfalfa, 2½ tons per acre. The yield of timothy seed ranges from 3 to 8 bushels per acre and of clover seed 75 to 100 pounds per acre.

Continuous cropping to corn and small grains, while rather common, is not practiced to as great an extent as on the heavier upland

soils, as the decrease in yields where this practice has been followed is more quickly noticeable on this lighter soil. In rotation, clover and timothy mixed is the most common hay crop, with but small acreages of clover alone and still smaller acreages of alfalfa. It is the common practice to keep the more rolling lands of this soil in permanent pasture. When in cultivation, such areas are sometimes cropped to rye as a fall forage and cover crop. Manure produced on the farm is practically the only fertilizer used. Little, if any, green manuring is done.

Land of this soil type ranges in value from $150 to $300 an acre, but average prices lie between $225 to $250 an acre.[7] Topography, improvements, and nearness to markets are the main influencing factors.

The keeping of more live stock, thus increasing the manure available for fertilizer, is to be recommended for this soil. Seldom is manure produced and applied in sufficient quantities to maintain fertility. Along with this a more common practice of crop rotation would be beneficial. An occasional green-manure crop may prove profitable. On the more rolling slopes the washing and leaching of the soil needs attention. The growth of cover crops, and in more severe cases of erosion the damming of gullies, are preventive measures recommended.

Clarion loam, rolling phase.—The surface soil of the Clarion loam, rolling phase, is a dark-brown to black moderately loose loam, 10 to 12 inches deep. The subsoil is a brown to dark yellowish brown, friable silty clay loam to silty clay, compact in places, which changes with increasing depth to a slightly more plastic silty clay loam, modified by a variable content of sand and pebbles. The color changes with increasing depth to a light brown or pale grayish brown, with segregations of gray calcareous material in places. The subsurface usually does not effervesce with acid, but the subsoil ranges from moderately to highly calcareous. Where highly calcareous the subsoil usually shows more gray stains and frequently contains limestone concretions. Bowlders occur locally throughout the soil and here and there are exposed on the surface, particularly in the most rolling morainic region.

The rolling phase is closely associated both with the typical Clarion loam and the types of the Pierce series. Near areas of the Pierce soils the subsoil is a light to heavy sandy clay, interbedded in places with shallow layers of sand and gravel at variable depths in the lower part. Where the soil profile is similar to the typical Clarion loam, separation on a topographic basis is often difficult. Usually, however, a lighter color and greater textural variation in the surface soil and a greater predominance of sand and gravel in the subsoil of the rolling phase constitute a basis for distinct separation. Where this soil difference does not exist in conjunction with the more rolling topography the land has been mapped with the typical Clarion loam. Where the phase is less extensive in the drift plains it occurs on isolated, narrow-crested elevations above the surrounding land or else on narrow, steep slopes leading from the uplands to the drainage ways.

[7] All land values given in this report are those that prevailed at the time of this survey (1920), when prices were somewhat inflated. Prices have since declined, and figures given should be regarded as relative only.

The rolling phase is extensive near the main streams and lakes. The largest areas are north of Swan Lake in Superior Township, between Bull Ditch and East Okoboji Lake in Center Grove Township, and between the Little Sioux River and West Okoboji Lake in Lakeville Township. The first-mentioned area represents the phase in its mildest relief; the other two areas are the most rolling and contain numerous slopes unsuited for cultivation. The topography of the phase as a whole, while not making cultivation impossible, renders it very difficult.

The drainage ways of the areas are comparatively deep, but are commonly irregular and tortuous and in places form simply a network of sloughs, as in the area near Bull Ditch in Center Grove Township. In the areas near Swan Lake and between the Little Sioux River and West Okoboji Lake the drainage ways are more regularly developed and have a slightly greater fall. Slope drainage is everywhere adequate and in most places erosion is active. Internal drainage is moderately developed, although where the subsoil is loose structured this also is excessive.

Parts of the rolling phase near lake shores and river valleys are occupied by remnants of the forest once present. In the main, however, the land was originally prairie. In its gentler rolling areas considerable of this phase is used for grain production, but probably two-thirds to three-fourths of its area is in pasture and hay land. Tame hay is increasing in acreage, but wild hay still predominates. Clover and timothy mixed and timothy alone are mostly grown, but some clover is grown alone. There is also a small acreage in alfalfa. Corn is the most important grain crop, followed closely by oats. Over half of these crops is fed to stock. Barley and wheat are raised to a small extent. The total acreage of small grains very nearly equals that of corn and is relatively greater than on the heavier upland types. Rye in a few instances is grown as a cover and fall-pasture crop. Some of the largest herds of live stock in the county are raised or fed on this soil. Hog raising is most important, but the cattle industry receives relatively more attention than on the heavier soils or the typical Clarion loam. Sheep raising ranks third. Dairying is less important and receives most attention on farms near local markets. Most of the sheep are raised for wool production. The fattening of western and home-raised lambs is receiving more attention.

Corn yields are usually higher than on the fine sandy loam upland soils and lower than on the typical Clarion loam, and average between 30 and 35 bushels per acre. Oats give an average of 30 to 35 bushels; wheat, 10 to 12 bushels; and barley, 20 to 25 bushels per acre. Cultivated hay averages from 1 to 2½ tons per acre. Alfalfa commonly gives the largest yields of hay, followed by clover, clover and timothy mixed, and timothy.

Farmers recognize the necessity of applying manure to obtain the best yields on this phase. The manure produced is applied mainly to the cultivated fields and in small amounts to the pasture lands. Corn is often grown only one year and seldom more than two years before cropping to oats, barley, or wheat. Occasionally on slopes where washing is severe contour plowing and cover crops are used to prevent erosion, but usually such areas are kept in permanent pasture.

Land of this type has considerable range in value. The more broken lands command little more than $100 an acre. The cultivable lands reasonably close to markets and fairly well improved sell as high as $225 an acre.

The maintenance of fertility through more liberal use of manure and measures to prevent erosion are the principal considerations in improving this soil.

CLARION SILT LOAM.

The surface soil of the Clarion silt loam is a dark-brown to almost black mellow silt loam, rather high in organic matter. Commonly the only change to a depth of 16 to 18 inches is a slight gradation to a lighter colored and heavier structured silt loam. Below this a light-brown to grayish-brown semiplastic silty clay loam is encountered. At greater depths the material becomes grayer and spots of pure gray are abundant. Throughout the subsoil concretionary lime material is commonly present, and in places the subsurface soil is also calcareous. Sand and pebbles are very seldom present in considerable quantities.

The Clarion silt loam occurs most extensively on the drift plains of Westport and Okoboji Townships. It is also an important type in Silver Lake and Diamond Lake Townships. It is closely associated with both the Clarion loam and Webster silt loam. Like the Webster silt loam, this soil has been formed by glacial deposition of the finest textured materials, but the better internal and surface drainage of the Clarion silt loam has resulted in the development of a better oxidized subsoil.

The topography of the Clarion silt loam is level to gently rolling. The areas southwest of Stony Creek, in Westport Township, have the most rolling topography, and the areas in Okoboji Township are the most nearly level. The natural surface drainage is moderately well developed in rolling areas. The internal drainage is everywhere inadequate and tile drainage is essential. The level areas in Okoboji and western Milford Townships have better internal drainage than the other areas, owing to the presence of thin layers of sand and gravel in the substratum at depths of 5 feet or more from the surface. Yet because of the level surface and consequent poor surface drainage, tile drains even there are required to put the land in the best possible condition for cropping.

The Clarion silt loam is one of the best agricultural soils of the county. Farm land of this type is usually in a high state of improvement. Corn, oats, hay, barley, and wheat, in the order named, are the most important crops. More live-stock feeding is practiced than upon the average farm of the county, and possibly half of the corn and more than half of the oats produced are utilized as feed. The largest hay acreages on the type consist of clover and timothy mixed and timothy alone, with smaller acreages of clover alone and alfalfa. Alfalfa is successfully grown only where good underdrainage is provided.

Hog raising is the most important live-stock industry, feeding and raising of cattle ranking next, and dairying and sheep raising being of still less importance. Nearer the markets, principally on areas in the vicinity of Milford, dairying is carried on to its greatest extent.

Dairy farms and those used in the larger feeding operations are usually equipped with silos, and from 110 to 120 tons of silage are put up annually. Corn yields average 45 to 55 bushels per acre or about 12 tons of silage, oats 30 to 50 bushels, wheat 20 to 25 bushels, and barley 25 to 35 bushels per acre. Clover and timothy, mixed, ordinarily gives yields of 2 to 2½ tons of hay per acre, and clover alone 2½ tons per acre.

Land of this type has an average value of $225 to $300 an acre, depending upon improvements and market facilities.

Crop rotation, which is becoming a more general practice, combined with the application of the large amounts of manure usually produced, serves to maintain this type in its naturally productive state. In all cases tile drainage is essential and drainage improvements on this soil are well advanced. The cost of tiling land of this type is lower than for the Webster soils.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Clarion silt loam:

Mechanical analyses of Clarion silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
334022	Soil, 0 to 18 inches	0.8	1.7	2.0	6.2	11.2	57.4	20.7
334023	Subsoil, 18 to 36 inches	.4	1.3	1.2	7.4	18.2	59.2	12.2

CARRINGTON LOAM.

The surface soil of the Carrington loam is a dark-brown to almost black loam. The subsurface layer, beginning at depths of 10 to 12 inches, is a brown to dark-brown semicompact silt loam, and this is underlain at 16 or 18 inches by a subsoil of compact, friable, light yellowish brown silty clay loam. The surface soil varies locally in texture from a heavy fine sandy loam to a light silt loam, being heavier and more uniform in texture in gently rolling areas than in more rolling areas. Variable quantities of sand and pebbles impart a light silty clay loam texture to the lower subsoil in some places. Thin layers of loose sand and gravel occur locally at variable depths in the subsoil. These layers are in most places coarse textured and lacking in uniformity, but in other places they are composed of uniform fine sand. Bowlders occur at various depths and are exposed here and there on the surface of slopes and knolls in the rolling morainic region.

A fine sandy loam variation of this type is found in small areas scattered throughout the county. These areas would have been indicated on the map as a separate type if they had been of sufficient extent.

Both the soil and subsoil are typically low in lime, but generally lime is abundant in the substratum at depths of 5 to 8 feet. In a few places this calcareous material occurs within the subsoil, but on the whole the lime content of the subsoil is very small.

The Carrington loam occurs mainly near the main drainage ways of the morainic region, but there are areas isolated from these

drainage ways, such as the one in sections 9, 10, and 11 of Milford Township.

In topography this soil closely resembles the Clarion loam, although a greater proportion of it has the rolling topography of the rolling phase. The topography is for the most part gently rolling to rolling. The area in sections 9, 10, and 11 of Milford Township occupies broad-crested elevations and gently rolling slopes. In sections 3 and 10 of Okoboji Township a still more level area lies between the Little Sioux River bluff and the outwash-gravel terrace to the east.

The natural surface drainage of the type is usually well developed. In rolling areas the slope drainage is erosional in places, and drainage ways run in irregular network fashion. Elsewhere, however, the land is not so severely dissected. Internal drainage is sluggish where the subsoil is compact and is more rapid in movement where the subsoil is sandy, which is more commonly the case in the more gently rolling areas. In such areas the internal drainage is better developed than the surface drainage.

This type everywhere shows the characteristics of a prairie soil, although some small areas were originally forested and still contain remnants of woodlands near lake shores and river valleys. The forests had so recently invaded these areas that sufficient time had not elapsed for the forest conditions to influence the soil. Bur oak, elm, and box elder are the most common trees found.

At present more than half of the type is in hay and pasture and the remainder is in grain crops. Practically all the land is utilized in some form of agriculture, the woodland affording some pasturage. Corn is the main grain crop, followed by oats, barley, and wheat. Corn yields range between those obtained on the Clarion loam and on the Clarion loam, rolling phase. The production of cultivated hay is greater than that of wild hay. Considerable live stock is kept on the pasture and hay lands, and over half of the corn and oats raised is fed to stock. Hog raising is the most extensive animal industry, followed by cattle raising, sheep raising, and dairying.

Corn is grown more continuously than on the rolling phase of the Clarion loam or the fine sandy loam upland types. Definite systems of crop rotation are practiced to some extent. Considerable quantities of manure are available and are applied. Rolling slopes, subject to washing, are usually kept in pasture. Tile drainage has proved beneficial in places.

Land of the Carrington loam ranges in value from $175 to $275 an acre. Topography, improvements, and nearness to market largely determine the price.

The addition of organic matter to this soil, both in the form of stable manure and green manure, is recommended. Keeping the land in sod is the best preventive for slope washing, but cover crops will aid in retarding erosion on cultivated slopes.

CARRINGTON SILT LOAM.

The Carrington silt loam surface soil is a dark-brown to almost black silt loam with a depth of 14 to 16 inches, and moderately compact below a depth of 10 inches. The gradual change to the subsoil of light-brown to yellowish-brown silty clay loam is first

noticed at depths of 16 to 18 inches. The subsoil is moderately compact, rather friable, and a little heavier below than above 20 inches. Neither soil nor subsoil is calcareous.

A variation from the typical profile occurs in a somewhat extensive area north of Spirit Lake in sections 8, 10, and 11. Here the surface silt loam gives way at 12 inches to a brown to dark-brown silty clay loam, which at 20 inches becomes dull yellowish brown faintly mottled with rusty-brown iron stains and plastic in structure. At 24 inches discolorations of gray and rusty brown are abundant, but the dominant color is a smooth brown to dark brown.

Where the Carrington silt loam is associated with loam upland soils, the boundaries are difficult to determine, and small areas of loam are included. The type has characteristics in common with the Clarion and Webster silt loams. It differs from the Clarion silt loam mainly in the absence of lime and certain details of structure, and from the Webster silt loam in having better natural drainage and a better oxidized, noncalcareous subsoil.

The Carrington silt loam has a total area of about 3 square miles and the individual areas are small. In places it occupies slope positions between the Webster and Clarion soils, between the Clarion or Webster and Lamoure soils, or between Webster and Carrington loam soils. In other places it occupies nearly level hilltops of small extent. The largest and most continuous areas are in Silver Lake Township, sections 7 and 18, where the soil is the dominant upland type and has a gently rolling topography.

Although the natural surface and internal drainage have been sufficient to effect rather complete leaching of lime and good oxidation of the subsoil, it is not sufficient for the best results in farming. Tile drains have been installed to improve this condition.

In its natural state the Carrington silt loam was covered with an abundant growth of prairie grass with little or no forest. About 75 to 80 per cent of the soil is in grain crops, and the remainder in hay and pasture. The pasture acreage is small because the type is generally associated with types better suited to permanent pasture. Although of small extent, it is recognized as one of the most productive soils of the county. Corn is the leading grain crop, followed by oats, wheat, and barley. Corn ordinarily averages 40 bushels per acre; oats, 35 to 40 bushels; wheat, 25 bushels. Other grain crops and hay crops yield about the same as on the Clarion and Webster silt loam soils.

The productiveness of this soil is more easily maintained than that of the upland loam soils. Barnyard manure is commonly used, but green manuring and other fertilizer practices receive very little attention.

The selling price of this type is affected by the value of adjoining soils as well as the topography, improvements, and market facilities. Values average about $250 an acre and range from $200 to $300.

The recommendations made regarding improved soil management of the Clarion silt loam apply equally well to this type.

WEBSTER SILT LOAM.

The Webster silt loam consists of a black silt loam high in organic matter, mellow in structure in the first 8 inches, but more plastic

below to 14 inches. The subsoil is a dark brownish gray, moderately plastic silty clay loam, which with increasing depth becomes rather plastic and heavily mottled with gray, rusty brown, and yellow brown. The subsoil is calcareous, and in many places the subsurface material effervesces with acid, but in only a few places is lime present in the surface soil. Sand, pebbles, and some bowlders are encountered within the soil profile, but rarely in appreciable quantities. The type in general is rather uniform.

A few areas, occupying what appear to be former lake terraces, have sufficient sand and gravel in the subsoil to impart a heavy sandy gravelly clay texture. Thin layers of sand and gravel are encountered at varying depths. In places on slightly elevated areas within the silt loam areas, or on small gentle slopes between the Webster silt loam and Clarion loam areas, or between these two types and the Lamoure soils of the traversing drainage ways, the surface soil contains quantities of the finer grades of sand sufficent to impart a loam surface texture. In areas closely associated with the Webster silty clay loam, areas of that type too small to map have been included, and separating boundaries are usually arbitrary. Where areas of the Clarion silt loam adjoin, the gradation to the better oxidized subsoil of that type is gradual and the boundaries are also arbitrary.

The Webster silt loam has been formed from the most uniform and finest textured glacial materials laid down on drift plains where the glacier accomplished its most perfect planing and where conditions have not been favorable for weathering and oxidation. The most notable change since deposition has been the accumulation of organic matter in the surface soil.

The Webster silt loam occurs most extensively in Milford, Lloyd, and Richland Townships on the drift plains of lowest elevation. It occurs less extensively on the higher drift plains of Westport Township and Excelsior Township and on an isolated drift plain in northwest Diamond Lake Township. Other small areas are found on gradual slopes and in level places in the less rolling parts of the morainic region.

The topography of the type is level to gently undulating. The natural surface and internal drainage is generally restricted and inadequate, and tile drainage is therefore nearly always essential. Occasional gentle slope positions have slightly better surface drainage. The best improved farms on this soil type have a tile investment of $25 to $30 an acre.

The Webster silt loam is naturally one of the most productive soils of the county. The only parts at present unfit for cultivation are those prevailingly in a saturated condition and as yet not adequately drained. Such areas support a rank growth of slough grass and are utilized only for pasture and the production of wild hay. Such was the state of the areas while in unsettled prairies. At present the greater part is cropped to grains. Corn ranks first, small grains second, and cultivated grasses for hay third. Continuous cropping of corn and small grains has been commonly practiced, but because of decreasing yields of grain, clover and timothy have slowly increased in acreage and crop rotation has become a more common practice. Farmers report increased yields of corn following clover and timothy in rotation. Clover alone is increasing in acreage, but

the clover and timothy mixture and timothy alone are most popular. Alfalfa is not so well adapted to this as to the loamy upland soils, but is grown successfully where thorough drainage is provided. Small grains have a tendency to lodge and rust in a wet spring season. Where drainage is good the damage is not so great, but even then the tendency is to produce straw at the expense of grain. Flax is commonly sown on newly broken areas of the type. Rape, millet, sorgo (saccharine sorghum), and buckwheat are sown to a limited extent, principally as catch crops.

Stock raising is better established than on the average farm of the Clarion loam. Hog raising is the most general live-stock industry, cattle raising ranking second, dairying third, and sheep raising fourth. The largest herds of cattle are usually kept where the pasture and hay acreages are the largest. On such farms the fattening of beef cattle receives considerable attention. On farms close to local markets dairying is growing in importance. Sheep raising is less general, but considerable numbers are raised for wool, and several carloads of western lambs are fattened for market each fall. Some purebred herds of cattle are maintained.

Corn averages 40 to 55 bushels per acre, oats 30 to 45 bushels, wheat 15 to 20 bushels, and barley 25 to 30 bushels per acre. Clover and timothy mixed produce 1½ to 2½ tons per acre, clover alone 2 to 2½ tons, and timothy alone 1½ to 2 tons. Where drainage is imperfect the yields are uncertain and average considerably lower.

Farmers crop this soil to corn and small grains more continuously than is the practice on the Clarion loam. Rotations are being adopted, however, as decreases in yields become noticeable. The soil is recognized to be better adapted to corn than to small grains, because of the tendency toward more luxuriant and slower maturing growth. For this reason all grain crops are planted as early as possible. Fall plowing, which makes possible an earlier seed-bed preparation the following spring, is practiced whenever possible. Early-maturing seed corn is especially demanded by farmers on this soil. Where the live-stock industry is engaged in, greater quantities of manure are produced and applied to the soil. Tile drainage is recognized as of prime importance and receives much attention.

The price of land of the Webster silt loam type ranges from $200 to $350 an acre, depending upon the state of improvement and proximity to markets. The average price is about $250 an acre.

Very little of this type is perfectly drained, and drainage improvement is of first importance. In spite of its high organic content crop rotation and applications of manure are beneficial.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the type:

Mechanical analyses of Webster silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
334027	Soil, 0 to 14 inches	1.2	4.6	3.0	8.6	9.1	52.4	21.1
334028	Subsurface, 14 to 18 inches	.7	7.2	5.1	7.4	8.0	46.5	25.1
334029	Subsoil, 18 to 36 inches	.5	5.1	5.3	8.1	8.4	51.7	21.0

WEBSTER SILTY CLAY LOAM.

The surface soil of the Webster silty clay loam is a black silty clay loam, high in organic matter, moderately friable when dry but plastic when wet, with a depth of 16 to 18 inches. The subsoil is a dark brownish gray plastic silty clay loam to silty clay, passing almost immediately into a lighter brownish gray color without appreciable change in structure and texture, but with heavy mottlings of light gray, yellow, and brown below 30 inches. The subsoil is calcareous and in places contains lime concretions. Sand and pebbles are present here and there in small quantities.

In depressions marking former swamp areas the surface soil is covered locally by a thin layer of well-decomposed Muck, and in a few places the subsoil contains enough sand and gravel to impart a heavy sandy gravelly clay or sandy clay loam texture. Areas in section 3 of Richland Township and section 33 of Superior Township have such a subsoil.

The Webster silty clay loam occupies the lowest upland depressions of the level drift plains. It occurs in close association with the Webster silt loam. In places it occupies an intermediate position between the higher Clarion loam and the lower lying level areas of Webster silt loam. Such a condition is illustrated by the area in section 26 of Richland Township. Another typical occurrence is in Diamond Lake Township on a level depressed drift plain or former swamp area between the forks of the Little Sioux River. Elsewhere within the morainic region the type occurs in former lake beds, former swampy or ponded areas, or in small areas of poor drainage at the head of upland drainage ways.

The topography of the Webster silty clay loam is level. Both the surface and internal drainage are poorly developed, and the greater part of the type at present is too poorly drained for cultivation.

A total area of about 6 square miles is occupied by this type. In their original state these areas were prairie sloughs and swamps. Slight improvements in the natural drainage, supplemented by artificial drainage, have improved their condition. About one-third of the type is at present sufficiently well drained for cultivation. This is used in the production of cultivated crops; the rest is pasture and wild hay land. Of the cultivated crops corn is far in the lead, followed by small grains and tame hay. Flax is frequently grown on newly broken tracts. Wild hay has a greater acreage than the cultivated grasses. Owing to the abundance of pasture and hay considerable live stock is kept.

Crop yields depend greatly upon the state of drainage. On poorly drained land corn yields only 20 to 30 bushels or even less per acre, but on land adequately drained the yields average 40 to 55 bushels per acre. Oats yield from 30 to 40 bushels on well-drained areas, and other crops produce as heavily as on the Webster silt loam. Tame hay grasses produce heavily as a rule. Clover and timothy, mixed, averages 2 to $2\frac{1}{2}$ tons; clover alone, $2\frac{1}{4}$ to $2\frac{1}{2}$ tons; and timothy, $1\frac{1}{2}$ to $1\frac{3}{4}$ tons per acre. The yield of wild hay is $1\frac{1}{2}$ to $1\frac{3}{4}$ tons per acre.

Farmers on this type give drainage first attention. Corn is grown to a greater extent than small grains, owing to the tendency of the latter to lodge, to suffer damage from rust, and to produce

straw at the expense of grain. Particular care is taken to plow only under favorable moisture conditions. Early seed-bed preparation and planting are recognized as essential. Crop rotations are not so generally followed as on the Clarion loam or silt loam, and less manure is applied. Trouble is sometimes experienced from alkali concentrations in narrow strips on the edge of former swamps and ponds, but the area affected is comparatively small.

The value of the Webster silty clay loam depends largely on its drainage improvement. Well-drained land commands as high prices as the Webster and Clarion silt loam soils.

The recommendations made for the Webster silt loam apply to this type in general. The areas affected by alkali require special treatment. Among the staple farm crops grown, oats have proved the most resistant and corn the least resistant to alkali, but the affected areas are seldom large enough to justify special cropping. Thorough underdrainage is the most essential step in the reclamation of such areas. The incorporation of manure and deep plowing render the surface soil more porous and favor the leaching action required to carry away the harmful salts. Under such treatment corn can usually be grown in a few years, although some farmers report alkali more lasting in effect and difficult to remove.[8]

PIERCE FINE SANDY LOAM.

The surface soil of the Pierce fine sandy loam consists of a brown to dark-brown fine sandy loam with a loose to moderately firm structure. The subsurface layer, between the depths of 10 and 18 inches, is a brown or dark yellowish brown loam to clay loam or clay, carrying sufficient coarse sand and gravel to give a texture and structure varying from a loose sandy clay loam to a moderately compact heavy sandy clay loam to sandy clay. As a rule the heavier material is present only in thin layers. The subsoil below 18 inches consists of loose sand and gravel with varying small quantities of silt and clay. Where it is heaviest, the subsoil is crumbly or slightly friable and scarcely less pervious than the loose, sandy, gravelly development. Bowlders are common throughout the soil section and on the surface but usually more abundant on the most rolling slopes and narrowest crested knolls and ridges. The subsoil, and in places the subsurface material, effervesces with acid. This indicates that the parent materials must have been high in lime content, for the soil profile is such that leaching is and always has been active.

The Pierce fine sandy loam occurs mainly in the rolling morainic regions adjacent to lakes or former lake beds and the principal streams. It is more or less closely associated with the Clarion loam, rolling phase, and boundaries between the two are in places arbitrary, owing to the variable occurrence of the loose sandy subsoil over the region, and the accompanying variation in surface-soil textures. Small areas of Clarion fine sandy loam and Clarion loam, rolling phase, are included within the areas of this type as mapped.

The topography of this type is rolling and in places steeply rolling. Isolated kames within the areas are characteristic topographic features. The most notable example is a kame in section 19, Spirit

[8] Iowa Expt. Sta. Bul. No. 157: Improving Iowa's Peat and Alkali Soils.

Lake Township, which rises to a height of about 50 feet. Usually the kames are only about 20 feet above the adjacent lands, but the slopes of practically all of them are eroded and bowlder strewn. The numerous small oval-shaped areas of Pierce fine sandy loam shown on the map are of this kame construction. Within the more extensive areas the kames are not so prominent and may be entirely absent, and they are seldom well isolated from the uneven topography prevailing. Another topographic variation of this type consists of ridges almost entirely surrounding former lake beds or small lakes and shutting them off from natural drainage outlets, as in the area around Sunken Lake in section 17 of Spirit Lake Township.

The surface drainage of the Pierce fine sandy loam is well established, being in places sufficiently rapid to cause erosion, and the internal drainage is free; consequently the drainage is generally excessive and the moisture conditions are favorable for crop growth only during periods of well-distributed rainfall. Where the underlying gravel and sand layer is thin, or where the subsoil is slightly heavier, the water-holding capacity of the type is somewhat greater.

The Pierce fine sandy loam occupies about 16 square miles of land in the county. Although chiefly a prairie soil, a considerable part of the type adjacent to bodies of water was originally in hardwood forest, and remnants of second-growth forest still exist. Bur oak, red oak, elm, box elder, haw, crab apple, and basswood predominate in these woodlands. At present about 40 per cent of the type is in grain crops, and the rest used as hay and pasture land. Corn is the most important grain crop, with oats second, followed by barley and wheat. The combined acreage of small grains is a little more than that of corn. More stock is kept than on the Clarion loam soils. Hogs, cattle, and sheep are the important livestock, ranking in the order named. Dairying is carried on to a small extent near market points.

On the better parts of the type corn yields from 25 to 35 bushels per acre. Unless the rainfall is well distributed corn generally suffers firing because of lack of moisture. Oats and other small grains ordinarily yield relatively better than corn, oats averaging 25 to 30 bushels; barley, 15 to 25 bushels; and wheat, 10 to 20 bushels per acre. Clover and timothy, mixed, yield three-fourths to 1½ tons of hay per acre.

Cropping is not so heavy or continuous on this type as on the heavier upland soils. Corn is seldom grown more than two years and sometimes only one year before changing to small grains and clover and timothy. Although at present but little grown, clover alone and alfalfa are increasing in acreage. The type receives special attention in the application of manure. Rye is sometimes grown as a cover crop on slopes subject to erosion, but in the main such areas are maintained in pasture. Areas of kame construction are seldom cropped, and then chiefly for tame hay. The gravel is sometimes utilized by the farmers for concrete work, but seldom are the deposits uniform or extensive enough for use in road surfacing.

Land of this type ranges in value from $100 to $250 an acre, depending upon the state of improvement and market facilities. Some of the land along the larger lakes brings a higher price because it is included in lake-shore lots.

For the improvement of this soil, manuring, crop rotation, green manures, and measures to prevent erosion are all essential. This soil responds well to fertilizers, but manure has not as lasting effects as upon the heavier upland soils, and more frequent and heavier applications are required. The more common use of legumes in the rotations and occasionally green manuring would be of benefit. Alfalfa can not be grown as successfully as on the Clarion and Carrington loam and fine sandy loam soils, but profitable crops are reported. Little trouble is encountered in obtaining clover stands, although these stands do not become so well established as on the upland types of heavier subsoil. The steeper areas are best kept in pasture, as is the common practice. Frequently a better pasture sod and the damming of gullies is needed in order to check erosion.

PIERCE LOAM.

The surface soil of the Pierce loam is a dark-brown to black, moderately compact loam, with a depth of 10 inches. The subsurface layer, from 10 to 18 inches, is a light-brown to yellow-brown, coarse, sandy to moderately heavy gravelly loam. In places it is rather compact, but such compact layers are thin and inextensive. The subsoil, 18 inches and below, consists of loose sand and gravel with small proportions of silt and clay, and varies in texture from a light coarse sandy clay loam to a loose porous sand or coarse sand. In general the subsoil materials are not stratified, but occasional small pockets show feeble stratification. Bowlders are present in the soil and on the surface, but are most numerous on kames and eroded areas. The subsoil is moderately to highly calcareous.

This type is closely associated with the Pierce fine sandy loam, and the two textures grade into each other so that in places the boundary is arbitrary. The kame formation also is a marked feature of this type. The loam type is not so extensively developed in large individual areas as is the fine sandy loam. The largest areas of loam are in sections 4 and 9 of Okoboji Township and sections 21 and 22 of Center Grove Township.

The larger areas include some moderately rolling land, but generally the topography is rolling, with slightly milder relief than on the fine sandy loam. Kame areas of this type, however, are usually more steeply rolling. A notable group occurs in sections 10 and 15 of Excelsior Township, where Dugout Creek meanders through a group of isolated kames of irregular arrangement having their longer axes in all directions. The erosion of their slopes has exposed in places a bowlder-clay stratum underlying the gravel and sand of the subsoil and substratum.

The internal drainage of the Pierce loam is not as rapid as that of the Pierce fine sandy loam, but surface drainage, except in a few places, is excessively developed.

The Pierce loam occupies about 9 square miles within the county. The greater part of the type is a prairie soil. The largest remnant of woodland in the county, however, is on this type and associated types on Gull Point on the southwest side of West Okoboji Lake.

The same type of agriculture and system of soil management prevails on the Pierce loam as on the fine sandy loam. The various crops

are grown to the same relative extent, and livestock is kept in about the same numbers. The proportion of the type cropped to grains is slightly greater than on the fine sandy loam, and the yields obtained range slightly higher as a rule, the loam being somewhat more productive, owing to a higher content of organic matter. Land values range a little higher than those of the Pierce fine sandy loam.

Recommendations for the improvement and management of the fine sandy loam apply equally well to the Pierce loam.

The table below gives the results of mechanical analyses of samples of the soil, subsurface, and subsoil of the type:

Mechanical analyses of Pierce loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
334011	Soil, 0 to 10 inches	1.1	6.2	5.3	26.3	12.2	32.8	16.2
334012	Subsurface, 10 to 18 inches	1.0	6.4	5 6	29.6	16.6	26.6	14.2
334013	Subsoil, 18 to 36 inches	30.1	37.5	9.0	12.6	3.7	4.6	2.5

DICKINSON FINE SANDY LOAM.

The Dickinson fine sandy loam surface soil consists of about 10 inches of dark-brown fine sandy loam, with a moderate content of organic matter. Underlying this to a depth of 18 inches is a light-brown to dark-brown slightly more compact loam, which in turn is underlain by a loose, porous sand to sandy loam, generally containing some coarse sand and gravel.

Locally the intermediate layer of heavier loam is thinner and less extensive, and in a few places it is entirely absent, practically the only texture change being to the coarser subsoil of sand or sandy loam. Gravel and coarse sand are more common in the soil profile of this type than in that of the Dickinson loam, and likewise bowlders are more numerous.

The Dickinson fine sandy loam occurs most extensively in Westport Township, in association with the Dickinson loam. Here it invariably occupies higher positions and its topography is generally more rolling. In the higher positions and those adjacent to streams the type occupies rolling to eroded slopes. Both the surface and internal drainage are excessively developed.

The Dickinson fine sandy loam occupies a total area of less than 2 square miles. About two-fifths of it is in grain crops, more in small grains than in corn. Pasture and hay land comprise the remainder. During extended dry periods the pasturage becomes sparse. The raising of cattle is the most important livestock industry, followed by hog raising, dairying, and sheep raising. Crop yields are lower than those on the Pierce loam and Dickinson loam. Heavy manuring is practiced where possible, as the lack of organic matter in this soil is everywhere recognized.

Land of this type ranges in value from $125 to $165 an acre, depending upon the topography, location, and improvements.

Methods for improving this soil are similar to those outlined for the Pierce fine sandy loam. Live-stock farming fits in best with the crop adaptation and manure requirements of this type.

Below are given results of mechanical analyses of samples of the soil, subsurface, and subsoil of the type:

Mechanical analyses of Dickinson fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
334045	Soil, 0 to 8 inches	1.6	8.9	5.8	30.3	13.1	28.3	12.3
334046	Subsurface, 8 to 16 inches	2.5	10.1	6.1	28.6	12.3	28.3	11.9
334047	Subsoil, 16 to 36 inches	2.3	8.6	7.4	49.0	20.4	8.0	4.3

DICKINSON LOAM.

The Dickinson loam consists of a dark-brown loam changing at 14 inches to a light-brown to brown heavy sandy loam to light loam, which at 20 to 24 inches changes to a light yellowish brown loose fine sand or sand. The subsoil is uniformly low in lime.

In two small isolated areas, one in section 10 of Milford Township, the other in sections 33 and 34 of Lakeville Township, the subsoil, beginning at a depth of 14 to 24 inches, consists of a brown to dark-brown brittle silty clay loam, and the loose sand is not encountered above 32 inches. These areas are arbitrarily separated from the heavy subsoil types surrounding them. Bowlders occur in the soil profile and on the surface over most of the type, though never in great numbers. The area in section 26 of Westport Township has the most bowlders and also has a subsoil spotted with pockets of coarse sand and gravel rather than the typical uniform sand and fine sand.

The Dickinson loam differs from the Pierce loam principally in the lack of lime and in the uniformity of the soil materials. It may have been formed from an older glacial drift or from materials of the same glaciation less resistant to weathering and less calcareous than the parent materials of the Pierce soils.

The Dickinson loam is developed mainly in Westport Township. It has a gently rolling topography but includes some level to undulating land. The slopes adjacent to the valley of Stony Creek are more rolling in places.

The surface drainage is well established, and the loose, porous structure of the soil insures thorough internal drainage; consequently the type is excessively drained during periods of light rainfall. Where the upper subsoil of heavier silty clay loam is present the water-holding capacity is greater. This latter condition exists in the isolated areas in Milford and Lakeville Townships and in small areas within the type as mapped in Westport Township.

A total area of less than 3 square miles is occupied by the Dickinson loam. In the southwestern part of Westport Township, however, it forms the predominant type over two sections. About 60 per cent of the area is cropped to grains and 40 per cent is used as hay and pasture land. Although corn has the largest acreage, the small grains occupy a larger proportional area than on the Clarion loam. Likewise a larger proportion of the type is devoted to hay and pasture, and more live stock is kept. Hog raising is the most common animal industry, followed by cattle raising and sheep raising. Dairying is

given little attention, owing to the distance from markets. Crop yields range a little higher than on the Pierce loam.

Farmers recognize that this soil is lower in organic matter than the heavier upland soils. Corn is not so continuously grown and small grains are grown more extensively. Clover and timothy, mixed, and timothy alone supply most of the tame hay. Live stock is kept in order to utilize the hay and pasturage. This soil can be worked under a wider range of moisture conditions than the heavier upland types, and planting of crops can usually be completed earlier in the spring.

Land of the Dickinson loam type sells for $150 to $200 an acre, depending upon the improvements and location with respect to markets.

The recommendations for the improvement and management of the Pierce fine sandy loam are also applicable to the Dickinson loam.

O'NEILL FINE SANDY LOAM.

The surface soil of the O'Neill fine sandy loam consists of 10 inches of dark-brown fine sandy loam. The subsoil is a variable, coarse-textured, sandy gravelly loam with a small percentage of silt and clay, which is more or less stratified and cross-bedded in the lower subsoil. Neither soil nor subsoil contains large amounts of lime.

The O'Neill fine sandy loam is practically confined to the outwash terraces on the east side of the Little Sioux River in Lakeville and Okoboji Townships. It occupies the bluffs of the O'Neill loam terraces adjacent to the river valley, and as a rule does not extend for any considerable distance back on the level terraces. Here and there the type occurs on elevated spots within areas of the O'Neill loam. North of Milford, in section 1 of Okoboji Township, there is an area of the type with a surface soil extending to a depth of 14 to 16 inches, much deeper than typical.

Along the larger lakes there are occasional areas of fine sand of beach-wash position and origin. While entirely different in origin and characteristics, these strips, where large enough to show on the map, have been correlated with the O'Neill fine sandy loam, which they resemble most. The material in these areas shows but little change from the light yellowish brown fine to coarse sand of the surface and has an exceedingly loose structure, being almost entirely free from silt and clay. The largest stretch of such lake-shore soil is mapped south of Spirit Lake.

The natural drainage of the fine sandy loam is more complete than that of the O'Neill loam, and crops suffer from drought during dry periods. A small part of the type is utilized for tame grasses, but most of it is kept in permanent pasture. Where the sand and gravel subsoil does not come so near the surface, as in the area north of Milford, grain cropping is practicable, however, and the methods recommended for the O'Neill loam will apply.

The value of this land is considerably lower than that of the O'Neill loam. Grazing is the only practicable use for the most of it.

O'NEILL LOAM.

The surface soil of the O'Neill loam is a dark-brown to black, moderately compact loam, about 12 inches deep. The subsurface layer to a depth of 18 or 20 inches is a dark-brown mellow silt loam

containing some coarse sand and gravel. The subsoil varies from coarse sandy loam to coarse sand and gravel containing little clay and silt, and at depths of 24 to 30 inches showing evidence of stratification. The subsoil to a depth of 3 feet is not calcareous, but tests of the material at a depth of 5 to 10 feet show effervescence, indicating the presence of lime carbonate.

A variation is noted in the south half of sections 25 and 26 of Okoboji Township and in less extensive areas elsewhere. Here the soil profile consists of a deeper surface loam of more compact structure, with the underlying heavy silt loam prevailing to a depth of 24 to 26 inches, in turn underlain by a deep subsoil of loose coarse sandy loam.

In another and more common variation the heavier silt loam subsurface layer is absent, the surface loam resting directly upon the loose sandy loam to gravelly loam subsoil. This profile is found in spots in sections 1, 2, 3, 11, 12, and 13 of Okoboji Township and in sections 6 and 7 of Milford Township, near the streams and drainage ways dissecting the terrace. The large gravel pits in the county are found in such areas, chief among which is the railroad pit south of Milford. Borings immediately west of Milford extended to 40 and 55 feet through gravel to the underground water level. Although no accurate data are available, such gravel depths are probably greater than the average underlying these terraces.

The most extensive area of O'Neill loam is in Okoboji Township adjacent to the Little Sioux River. This terrace, locally known as the Milford terrace, occupies an area of about 10 square miles, and has a level surface broken only by a few drainage ways. Elsewhere the areas of the type are small and are developed mainly in proximity to streams and lakes or former lake beds. A few small isolated areas are found within the uplands and entirely separated from natural drainage features. Such areas, as well as those on the terraces, occurring as they do at high elevations above the lakes and streams, indicate that the agency in their formation must have been the streams issuing from the glaciers during their period of rest and recession.

The O'Neill loam occupies flat benchlike terraces usually 50 feet or more above the first bottoms. This elevation is maintained over practically all of the area in Okoboji Township, except the part in sections 31, 32, 34, and 27, which is only 20 feet above the river bottom. Along the east fork of the Little Sioux River, in Diamond Lake Township, the type also occupies a lower terrace averaging from 15 to 20 feet above the bottoms. Generally the areas of greatest elevation are the largest.

The natural drainage of the O'Neill loam is excessive, owing to the deep underlying stratum of loose sand and gravel. Where the surface loam is deeper than typical or where the subsurface material approaches the texture of a silty clay loam or where the gravel substratum is thinner the type has a greater water-holding capacity. Likewise areas of the least elevation above the ground water level are more drought resistant than the higher terraces.

The O'Neill loam occupies an area of nearly 14 square miles and is an important soil. About 70 per cent of it is in grain crops and the rest is in pasture and hay lands. All the crops commonly grown in the county are found on this type. Small grains and tame hay

occupy a larger proportion of the land than on the Clarion loam. Corn occupies but a little greater acreage than small grains. Raising and fattening hogs and cattle constitute the most extensive livestock industries. Dairying receives considerable attention near local markets. Sheep raising is engaged in near the main streams.

Crop yields vary with the rainfall during the growing season, the highest yields being obtained in seasons of well-distributed rainfall. Year in and year out corn will average about 30 bushels per acre; oats, 25 to 30 bushels; barley, 20 bushels; and wheat, 15 to 20 bushels per acre. Clover and timothy, mixed, give about 1 to 1¼ tons of hay per acre.

The O'Neill loam has many advantages for farming. It is level and comparatively free from gravel and has a well-aerated soil that can be cultivated in early spring and throughout the season under a wide range of moisture conditions. As a rule corn is a more uncertain crop than small grains. Frequently corn land is put to small grains after one year. Where a systematic rotation is followed the small grain is usually followed by clover and timothy, mixed. Crop rotation is more commonly practiced than on the Clarion loam. More manure is applied, and occasionally the fall growth of clover is plowed under as green manure instead of being used for pasture, as is the more common practice on heavier soils.

Land of the O'Neill loam sells for $150 to $200 an acre. Proximity to market or an especially good state of improvement raises the price.

Owing to the comparatively low content of organic matter and the excessive internal drainage this soil requires heavy manuring, occasional green manuring, and a more common practice of crop rotation with legumes in order to increase production and maintain fertility. Keeping more live stock is recommended in this connection. The application of lime is a special need where alfalfa is sown.

SIOUX LOAM.

The surface soil of the Sioux loam is a dark-brown loam, moderately compact at the surface and gradually changing to a coarser loam of less firm structure. At an average depth of 14 inches this is underlain by loose, feebly stratified sand and gravel, exceedingly variable in texture, with small percentages of silt and clay. The subsoil is moderately to highly calcareous.

A variation from the typical profile occurs in an area occupying a slightly elevated position on a terrace in section 12 of Silver Lake Township, where the surface soil is a coarse loam approaching a coarse sandy loam. Similar surface material is also found elsewhere on slightly elevated spots bordering on first bottoms. Small strips lying between this soil and Fargo soils consist of a light silt loam underlain at varying depths by sand and gravel. One such area is in section 16 of Westport Township. Another variation occurs in areas of the type on low terraces sloping gradually to Muck beds. Here the surface loam contains enough organic matter to give it a slightly mucky structure at the immediate surface.

The Sioux loam is developed mainly along Stony Creek in Excelsior and Westport Townships, but occurs elsewhere on low terraces. On the higher terraces the formation of the type has no doubt been similar to that of the O'Neill loam. On the low terraces the gravel

outwash deposit previously formed the bed of swamps and ponds left by the retreating glacier. Such was the character of the upper valley of Stony Creek until a dredge ditch provided an outlet for the swamp waters. On the lower terraces the type occurs more closely associated with the Fargo soils. The Sioux loam differs from the O'Neill soils principally in its lower position, thinner surface soil, and the higher lime content of the subsoil.

The Sioux loam occupies level terraces in most places only 5 to 10 feet above the adjacent stream bottoms or lake beds. Occasional areas occur at elevations of 15 to 20 feet. The gravel substratum affords drainage, which is usually excessive, and in places subject to occasional overflow it provides rapid escape for the water. This soil can not supply moisture to crops over long dry spells. Areas of the least elevation above the ground-water level are the most drought resistant.

The Sioux loam occupies about 4 square miles in the county. About three-fifths of it is in grain crops and the rest in hay and pasture. Corn and small grains are grown on about equal acreages. Over half of the hay is wild hay, but the area in tame hay is increasing. Cattle and hog raising are the principal live-stock industries, and are usually a part of a system of general farming.

Corn produces a smaller stalk growth and a lower yield than on the O'Neill loam, owing to the thinness of the surface soil and low fertility of the gravel subsurface layer. The shallower feeding small grains give more satisfactory yields. Tame hay yields from three-fourths ton to 1½ tons per acre and wild hay about one-half ton lower.

As a rule more manure is applied to grain fields on this type than on the Clarion loam. Very little green manuring is done, and legumes are not commonly grown except in a mixed seeding of clover and timothy.

Land of the Sioux loam type ordinarily ranges in price from $125 to $150 an acre, but well-improved farms situated near markets sell as high as $200 an acre.

The keeping of more live stock, heavier and more frequent applications of manure, and a more extensive use of legumes in the rotations, occasionaly plowing them under for green manure, are practices that should prove beneficial. A considerable proportion of the land is probably best suited for pasture. Where the surface soil is quite thin and drainage exceedingly rapid the attempt to maintain the land in a condition suitable for growing cultivated crops would probably be unprofitable.

FARGO SILT LOAM.

The Fargo silt loam has an almost black heavy silt loam surface soil high in organic matter. At 10 inches the subsoil is a black to dark brownish gray silty clay loam, which, with increasing depth, gradually is displaced by a light to dark brownish gray plastic silty clay, and the lower subsoil is mottled with yellow, gray, and rusty brown. The subsoil and in places the surface soil is highly calcareous. Where associated with the gravelly-subsoil terraces, the subsoil locally contains a thin layer of fine sand to coarse sand and gravel, appearing in most places at a depth of 18 to 20 inches.

The total area of this type in the county is less than 2 square miles. The individual areas are small, the most important being those along Stony Creek in Westport Township and those in section 23 of Excelsior Township.

The Fargo silt loam occurs on low level terraces lying along the main drainage ways. The average elevation above the bottom is about 10 feet, but some areas are low enough to suffer occasional overflow and others lie 20 feet above the overflowed bottoms. In all cases natural surface and internal drainage is sluggish.

A little over half of this type is in grain crops and the rest in hay and pasture land. Corn is the principal cultivated crop, followed by hay grasses and small grains. Corn yields from 20 to 50 bushels and oats from 20 to 40 bushels per acre, depending upon the drainage. Cultivated hay yields from 1 ton to 2½ tons, and wild hay from 1 ton to 1¾ tons per acre. Considerable livestock is kept.

This soil, when well drained, is recognized as an excellent soil for corn, but not so well adapted to small grains, because of the rank stalk growth and light grain production. Although the type is high in organic matter, farmers report that manure increases its productiveness.

The value of the Fargo silt loam depends largely upon the state of drainage improvement. The usual range in price is from $125 to $225 an acre.

But little of this soil is adequately drained, and in its present state of drainage the type is best utilized as pasture and hay land.

The practices followed on the Webster silt loam are recommended for this type.

FARGO SILTY CLAY LOAM.

The surface soil of the Fargo silty clay loam is a nearly black silty clay loam, with a depth of 16 inches. The subsoil is a dark brownish gray plastic silty clay to a depth of 24 inches, and below that a light brownish gray clay mottled with yellow, gray, and rusty brown. The surface soil is calcareous in places and the subsoil is everywhere highly calcareous.

This type is closely associated with the Fargo silt loam. It usually occurs on slightly lower and more imperfectly drained parts of the low terraces than does the silt loam. The areas range in size from 10 to 120 acres, the largest being those near Hottes Lake and Grovers Lake, in Spirit Lake and Diamond Lake Townships, and along Stony Creek, in Westport Township.

This soil is handled in the same manner as the Fargo silt loam. The larger areas are used for hay and pasture, only about one-fourth of the type being in grain crops. Slough-grass hay forms the larger part of the wild hay harvested. Clover and timothy, mixed, and timothy alone are grown for hay. Corn yields about the same as on the Fargo silt loam, but the yields of small grains average a little lower. Wild hay in many years yields 1½ to 1¾ tons per acre.

Drainage improvement is essential to the successful farming of this type. Only a few of the cultivated areas are at present adequately drained. Great care must be taken to work this soil only under favorable moisture conditions, and consequently clean cultivation is difficult during an average spring and summer season. Man-

ure is frequently plowed under in order to modify the tenacious structure of the surface soil.

Land of this type ranges slightly lower in value than the Fargo silt loam.

Although this soil is naturally productive, it is not well suited to cultivated crops, because of a high water table and sluggish drainage. It gives good crops of hay and excellent grazing, and these would seem to be the most practical uses of the type. For cultivated crops the practices recommended for the Webster silty clay loam apply equally well to this soil. A little of the land is affected with alkali in much the same way as the Webster silty clay loam.

LAMOURE SILTY CLAY LOAM.

The surface soil of the Lamoure silty clay loam consists of a black silty clay loam, high in organic matter, moderately friable when dry and rather plastic when wet. From 10 inches down to 18 inches the material is more plastic and contains less organic matter. The subsoil below 18 inches is a brownish-gray to dark-gray silty clay loam to silty clay and below 24 inches it is a lighter brownish gray silty clay, mottled yellow, gray, and rusty brown, very compact and stiff when dry and very plastic when wet. The subsurface and subsoil, and in places the surface soil as well, show the presence of lime.

Locally at a depth of 20 inches the subsoil grades into a light grayish or yellowish brown sandy clay, in places rather coarse in texture. This variation is more commonly found in areas occupying former pond or swamp positions than in areas occupying upland swales and larger stream bottoms. In another variation from the typical soil profile the subsoil changes with increasing depth to a dark brownish gray to black plastic silty clay free from mottling. This most commonly occurs in positions where permanent saturation prevails.

Variations in the surface soil occur in a number of areas of this type. In areas adjoining Muck beds, a surface layer of 1 to 4 inches of Muck is found in places. This Muck is usually in an advanced state of decomposition and so well incorporated with silt and clay as to impart only a slightly mucky structure. In areas occupying narrow upland-swale positions, the materials washed from the adjacent slopes have modified the surface soil in places to textures of loam or silt loam. Such areas were too small to map separately. These lighter textured surface soils occur also in the larger stream bottoms where they occupy natural levees along the banks. Here the textural change is gradual, the loam on the bank grading through a silt loam to a silty clay loam with increasing distance from the channel.

The Lamoure silty clay loam has been formed from the silty drift-plain sediments of sluggish streams and stagnant waters. It occupies all of the upland drainage ways and swales and practically all the larger stream bottoms of the county. Along the Little Sioux River—except in Lakeville and Okoboji Townships—and along Muddy Creek and Stony Creek the bottoms of this soil are generally not more than one-fourth mile wide. The largest and widest stream-bottom area lies at the union of the two forks of the Little Sioux River. However, it is in former lake-bed positions that this type

occurs in its more extensive single areas, the largest of which is in sections 23 and 26 of Excelsior Township.

The topography is nearly level or very slightly sloping. In areas of permanent saturation the growth of bunch or tuft grasses results in a hummocky condition. The natural surface and internal drainage is very poor, and a considerable part of the type is almost permanently saturated from the periodic overflows.

Inasmuch as this type occurs on practically every farm in the county, it must be considered a soil of some importance, despite its small cultivable area. In narrow swales, small stream bottoms, and small former swamp and lake beds, the Lamoure silty clay loam supports a fine growth of slough grass, which is utilized for pasturage and occasionally cut for hay. A greater proportion of this soil than of any other is utilized in this way. Farms with much of this soil carry more stock to utilize the hay and forage provided. Cattle grazing is the most important animal industry, followed by hog raising and some sheep raising. Dairying is receiving more attention in sections near local markets. Except where included in cultivated fields with adjoining types, only the larger areas are cultivated, and only a few of these are in good cultivable condition. On land in good condition for cropping, corn yields from 45 to 55 bushels per acre. Small grain yields are relatively lower. Hay grasses produce heavily, clover and timothy mixed yielding 2 to 2½ tons per acre. Wild hay averages 1½ tons per acre.

In the improvement of the Lamoure silty clay loam the procedure is most commonly as follows: Thorough tile drainage is installed, and for several seasons, during which the soil remains refractory, pasturing, cropping to hay, flax, potatoes, or some short-season crop is followed. The cropping systems followed thereafter are practically the same as on the upland Webster soils. Small grains, however, are less well adapted to the Lamoure and are not grown quite so extensively as on the Webster. Clean cultivation is difficult, because this soil can be worked only under the most favorable moisture conditions. Manure is incorporated in small quantities to improve the physical structure of the soil and maintain fertility, but should be applied only after the small grain crops, where they are grown.

When well drained and improved the Lamoure silty clay loam is as productive and valuable as any soil in the county. Very few farms have enough of this type to give an actual basis of valuation, but the type is included in practically every tract of land. Where it severely dissects a tract of upland soil this type detracts from the value, but where it is more extensive and in good cultivable shape the value of the adjoining land is enhanced.

Thorough drainage is the great need of this type, and where the areas are large enough to make their cultivation economical the heavy cost of laying tile drains is repaid in a few years of cropping. Although naturally fertile, the type is benefited by the incorporation of small quantities of manure, especially after periods of heavy cropping. Some areas are affected with alkali in a manner similar to the Webster and Fargo soils. The mode of occurrence and origin of this alkali are discussed in connection with the Webster silty clay loam, and the remedial practices followed and recommended for that type apply equally well to the Lamoure silty clay loam.

WABASH SILT LOAM.

The surface soil of the Wabash silt loam is an almost black silt loam 10 to 12 inches deep. The subsoil consists of a black silty clay loam, which becomes slightly mottled with gray and rusty brown at 24 inches and below. Neither soil nor subsoil is highly calcareous.

This type, which is small in extent, occurs chiefly on the higher bottoms of the Little Sioux River in Lakeville and Okoboji Townships. Over these bottoms the texture of the surface soil varies locally from a fine sandy loam near the stream to a heavy silt loam at greater distance from the channel. The type lies practically level and is subject to periodic overflow, making crops somewhat uncertain. The internal drainage of this soil is nevertheless much better than that of the Lamoure silty clay loam, and only a very small part of the type is permanently water-logged, so that if protected from floods it should become a good agricultural soil.

The Wabash silt loam is not important in the agriculture of the county. Except for a few small fields, it is all used for grazing cattle, sheep, and hogs. Excellent pasture stands are maintained. The soil is managed the same as the Lamoure soil and has the same cropping qualities. Being used almost entirely for pasture, the value of the land is less than it would be if there were cultivable areas of considerable extent. Actual selling prices are difficult to determine, since they depend largely upon the value of adjoining lands.

MUCK.

The surface material of Muck consists of partly decomposed organic matter derived from former swamp and lake-bed vegetation, mixed with varying proportions of silt and clay and smaller proportions of sand washed from adjoining slopes. This material extends to an average depth of 16 inches. The subsoil is a black plastic silty clay loam, which usually becomes a dark to light brownish gray highly calcareous silty clay in the lower subsoil. The organic matter at the surface is typically a fairly well decomposed black mass, exceedingly light in weight and fluffy when dry, but when wet it is moderately tenacious.

Occasional areas have about 2 inches of peaty material on the surface, and a few areas in which this peaty material extends to a depth of 10 to 12 inches are included with the Muck, as mapped. In spots the subsoil consists of coarse sand and gravel, as in the area in sections 19 and 20 of Superior Township.

Muck occurs mainly in former swamp and lake beds of constructional formation and restricted drainage, but it occurs also in a few places in the Little Sioux River bottoms. The average size of the individual areas of Muck is not over 30 acres. Only nine areas occupy more than 100 acres each, the largest containing about 200 acres.

The natural drainage of Muck beds is exceedingly poor, owing more to their position in low areas of obstructed drainage than to poor internal drainage. In fact, where adequate artificial drainage is provided, Muck responds rapidly in improvement. The high organic content of the surface material favors free percolation of water to the tiles.

Artificial drainage in most cases has been established only since 1916 and 1917, and few of the areas are at present in cultivable shape. After drainage the land is usually pastured or used for hay for three or four years before it is cultivated for corn or small grains. Corn is the principal crop on reclaimed Muck. Small grains invariably produce an overabundance of straw at the expense of grain, and considerable loss from lodging results. The yield of wild hay is about 1½ tons per acre, and of cultivated hay somewhat more. Areas permanently saturated can be used only for pasturage and occasional cuttings of wild hay.

Alkali occurs in places on the borders of Muck areas and tends to limit production. These spots can be improved by the measures outlined for the treatment of alkali spots in the Webster silty clay loam. The Muck is productive and no manure is applied, except on alkali spots.

Muck with fair drainage is valued at about $170 an acre. In its present state of improvement its value ranges from $65 to $200 an acre, depending mainly on drainage improvement, location with respect to markets, and value of surrounding soils included in the sale.

Two areas of Peat occur in the county, one of 70 acres in sections 24 to 25 of Richland Township, and the other of 130 acres in section 1 of Lloyd Township. On account of the small total area of this material it has not been mapped as a separate type, but has been included with the Muck.

The surface layer in these areas consists of 10 to 12 inches of a brownish mass of partly decomposed organic matter of fibrous structure, intermixed with varying small proportions of clay, silt, and fine sand. This is underlain by a dark brownish gray silty clay loam to silty clay containing organic matter to a depth of 24 inches. The subsoil is invariably highly calcareous. In places the subsoil is more sandy or is entirely composed of materials varying from fine sand to coarse sand and gravel. Peat differs from Muck only in the lesser degree of decomposition of the organic matter. In origin, manner of formation, and mode of occurrence the two are identical.

The methods of improvement practiced are similar to those used for Muck areas. Peat, however, does not respond so rapidly owing to the greater proportion of comparatively raw organic matter in the surface layer.

Both areas of Peat have been partly drained, but are not yet in the best cultivable shape and are used mainly for pasture and hay land. In their present state of development they have a lower value than Muck.

SUMMARY.

Dickinson County is situated in northwestern Iowa, just south of the Minnesota State line and in the third tier of counties east of the South Dakota State line. It is rectangular in shape and comprises an area of 376 square miles.

The topography varies from rolling to undulating and level, averaging a gently rolling relief. The average elevation is about 1,425 to 1,450 feet above sea level.

The Little Sioux River and Muddy and Stony Creeks handle practically all of the drainage. Drainage ways reach all parts except

the level drift plains, but the drainage is sluggish and the channels range from tortuous to moderately regular in development. The main stream valleys are, with but few exceptions, disproportionately wide and little eroded. Dickinson County is known as a county of lakes, 24 square miles being so occupied. Spirit and Okoboji Lakes are popular as summer resorts.

Dickinson County was organized in 1857, and has enjoyed steady growth and settlement. The census of 1920 reported a population of 10,241. There are seven incorporated towns in the county, Spirit Lake, the largest, being the county seat.

Three railroads furnish good transportation facilities to terminal markets. A good system of county roads makes the hauling of farm products to local markets comparatively easy.

The annual mean rainfall is 31.89 inches, usually well distributed over the growing season. The mean annual temperature is 43.7° F., the summer mean is 68.7° F. and that of winter, 15.9° F. The average frost-free season is 140 days, from May 10 to September 27.

A general farming type of agriculture prevails. Corn is the principal cash crop, and oats are second in importance. Barley, wheat, flax, and buckwheat are other grain crops grown. Cultivated hay ranks third in acreage. Live-stock products marketed are second to grains in value. Hog raising, raising and fattening cattle, dairying, and raising and fattening sheep are the live-stock industries, mentioned in the order of their importance.

In 1920, 1,043 farms of an average size of about 200 acres were reported; 612 were operated by tenants. The average farm-land value in the county was between $175 and $225 an acre at the time of this survey (1920).

The soils of the county are divided into three main groups, upland soils, terrace soils, and bottomland soils. In all there are 18 types, representing 10 different soil series, and 1 miscellaneous classification, Muck.

The Clarion, Carrington, and Webster soils of the upland are heavy-subsoil types comprising the most extensively cultivated and most productive of the upland soils. The Pierce and Dickinson soils are lighter textured subsoil types that are less productive and less extensively cultivated. The Clarion loam, Clarion silt loam, and Webster silt loam are the types of greatest extent, the former by far predominating.

The O'Neill and Sioux soils are the light-subsoil types of the terraces and the Fargo soils are the heavy-subsoil terrace types. Of these the O'Neill loam is the most extensively cultivated.

The bottom soils are chiefly of the Lamoure series with smaller areas of the Wabash series. These soils are used chiefly for pasture and hay, although under careful cultivation they are very productive.

Muck is found only in former swamp and lake beds, in which the drainage has been obstructed. Very little of it is in cultivation.

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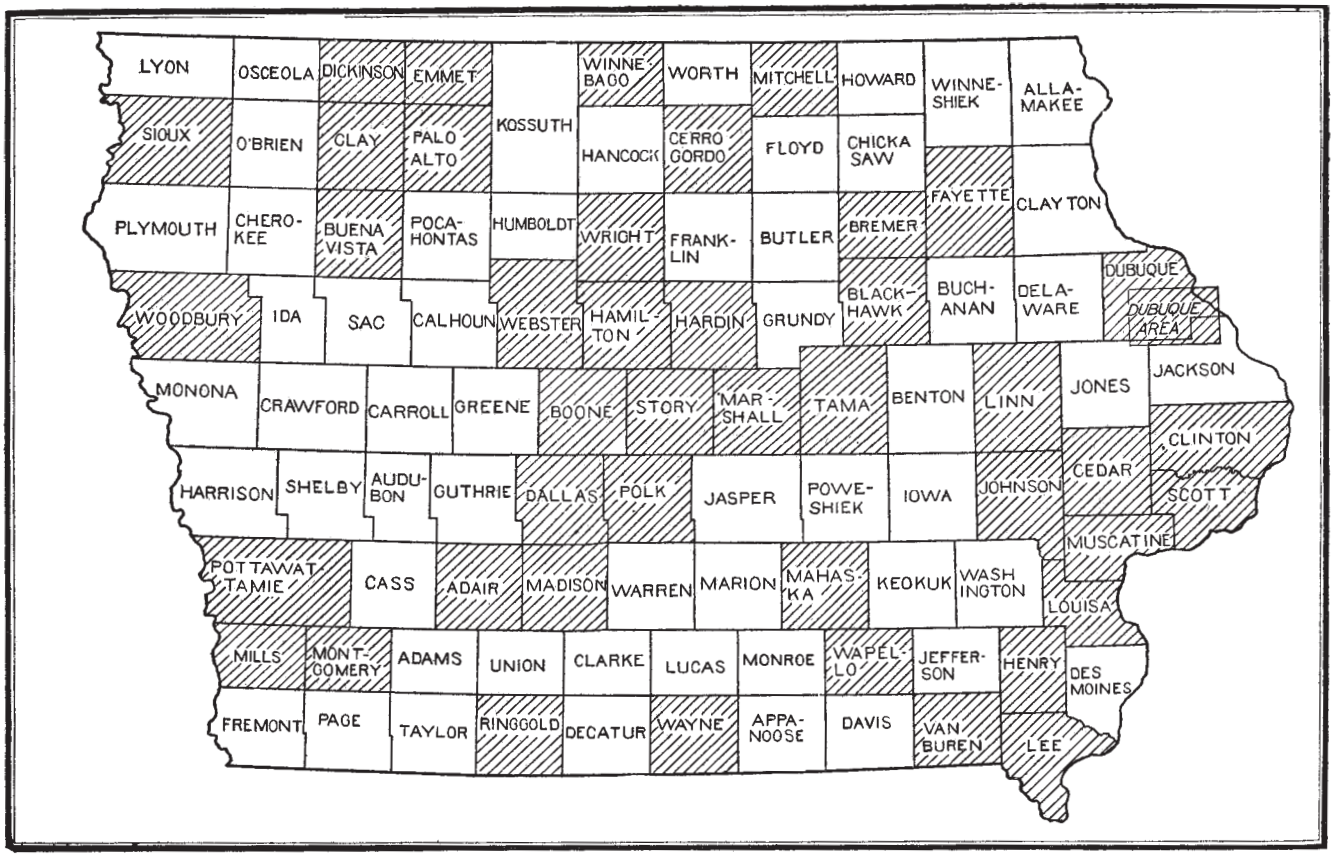

Areas surveyed in Iowa, shown by shading.

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