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

SOIL SURVEY OF O'BRIEN COUNTY, IOWA.

BY

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[Advance Sheets—Field Operations of the Bureau of Soils, 1921.]

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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, O'Brien County sheet, Iowa.

SOIL SURVEY OF O'BRIEN COUNTY, IOWA.

By J. AMBROSE ELWELL, of the U. S. Department of Agriculture, in Charge, and H. R. MELDRUM, of the Iowa Agricultural Experiment Station.

DESCRIPTION OF THE AREA.

O'Brien County, Iowa, lies in the northwestern corner of the State, in the second tier of counties east of the South Dakota State line and in the second tier of counties south of the Minnesota State line. Primghar, the county seat, is about 75 miles northwest of Sioux City. The county is approximately square in shape, comprises 16 townships, and has an area of 569 square miles, or 364,160 acres.

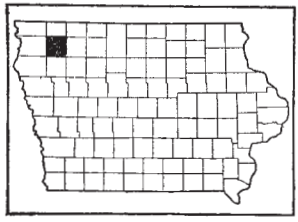

FIG. 10.—Sketch map showing location of the O'Brien County area, Iowa.

The county comprises loess-covered drift plains, more or less modified by erosion, and varying in topography from level to undulating, with the valleys of the streams that have worked upon the original plain surfaces. The most notable topographic feature of the county is the almost level undissected drift plain of the extreme eastern part of the county which is bordered on the west by the valley of Waterman Creek and on the north by the valleys of drainage ways flowing into Clay County from near Hartley. Undulating topography characterizes areas of variable extent in all but the northwestern quarter of Baker Township, in the northern part of Dale Township, the western parts of Lincoln and Hartley Townships, and in Floyd Township in the proximity of Ritter. Narrow strips of rolling to hilly topography are found along the west bank of Waterman Creek and its main tributaries to the west. In southern Grant Township and Waterman Township these border strips become slightly wider and the slopes to the drainage ways are steeper. Rolling to hilly land is practically restricted to the main drainage ways in the county and is nowhere extensive. Moderately rolling topography prevails over the southern tier of townships, and is more or less extensive in the watershed of the Floyd River in Franklin Township, south of the Floyd River in Floyd Township, and in the northern parts of Carroll and Summitt Townships.

The main bottom lands are along the Ocheyedan, Little Sioux, and Floyd Rivers and Waterman Creek. The valleys of the Little Sioux River and the lower courses of both Waterman and Mill Creeks are narrow, almost gorge-like in places, and the bottom lands show faint ridging from the action of periodic flood waters. The upland rises from the deeper valleys in steep abrupt slopes, with only narrow strips of mixed alluvial and colluvial material lying at the foot of the slopes.

Elevations range from approximately 1,375 to 1,552 feet above sea level, the average elevation being about 1,450 feet. The highest divide extends from eastern Franklin Township in a southeast direction as far south as Gaza. From the divide the land has a slight

slope to the west, south, east, and northeast. In general the greatest slope is from the divide at Gaza southeast through Waterman Township to the corner of the county.

The Little Sioux River, the largest stream, flows through Waterman Township, but only about 5 miles of its course lies within the county. Its tributary, Waterman Creek, is the main drainage outlet for Waterman, Grant, eastern Center, western Omega, Lincoln, and western Hartley Townships. The level plain east of this creek has practically no natural drainage. The tributaries of Waterman Creek to the west extend an average distance of about 5 miles and furnish excellent natural drainage for its watershed in Waterman and Grant Townships. The drainage of its watershed in the northern half of the county is not so thorough, and through Lincoln and Hartley Townships the course of Waterman Creek resembles a sluggish prairie slough.

The Ocheyedan River traverses the extreme northeast corner of Hartley Township for a distance of 2½ miles. It occupies a constructional valley, has little tributary development, and drains its watershed rather imperfectly.

Mill Creek has the largest watershed and drains an area comprising the central, south central, and southwestern parts of the county. The tributaries to the west and northwest in Baker and Summitt Townships and the head of Mill Creek itself in Center Township are poorly developed, and this part of the watershed is imperfectly drained. The remainder of the watershed is drained fairly well.

The Floyd and Little Floyd Rivers furnish the natural drainage for the northwest and north-central parts of the county. Tributary drainage is best developed at the head of Little Floyd River, but even here it is imperfect. These streams in the main flow through constructional valleys, with narrow watersheds, and their upper courses have much of the character of a prairie slough.

The depth of the stream valleys varies from 10 to 150 feet. The deeper dissection is in the Little Sioux River and Waterman Creek Valleys in Grant and Waterman Townships. The lower course of Mill Creek in Union Township lies in an erosional valley about 35 to 50 feet below the adjacent uplands. The constructional valley of the Ocheyedan River in Hartley Township has about the same depth. The lower Floyd River Valley in Floyd Township is about 25 to 30 feet below the uplands. Up the river the valley gradually becomes narrower and shallower until in Lincoln Township the course becomes scarcely more than a prairie slough. Following northward along the course of Mill Creek there is a similar transition.

O'Brien County was formed in 1860. The first settlers arrived in 1856, but settlement was not very active until 1868. The settlers were mainly from eastern Iowa and Illinois, with a few from the Middle Eastern, Eastern, and Southeastern States and some who came directly from Germany and other countries of northwestern Europe. Unofficial enumerations give the population as 30 in 1865, 715 in 1870, and 2,349 in 1875. The Federal census of 1880 reports a population of 4,155, which was tripled between 1880 and 1890. According to the 1920 census the population is 19,051, of which 81.7 per cent is classed as rural. The rural population has an average density of 27.4 persons per square mile and is quite uniformly distributed. In Liberty, Baker, and Caledonia Townships the population is pre-

dominantly German, and in Floyd Township it is largely Dutch. There is also a Quaker community of some size south of Primghar in eastern Dale and western Highland Townships.

Sheldon, the largest town, with 3,488 inhabitants, is also the oldest, having been incorporated in 1876. Sanborn, which was incorporated four years later, ranks second in size, having a population of 1,497. Primghar, the county seat, is situated in the center of the county and had a population of 972 in 1920. Other incorporated towns are: Hartley, with a population of 1,306; Paullina, with 987; Sutherland, with 876; Calumet, with 266; Archer, with 184; Moneta, with 127.

Two railways traverse the county east and west, two northwest and southeast, and one crosses the extreme northwest corner, furnishing excellent transportation facilities for all parts of the county. Sheldon is the junction of the Chicago, St. Paul, Minneapolis & Omaha, the Illinois Central, and the Chicago Milwaukee & St. Paul Railroads, and Hartley is the junction of the Chicago, Milwaukee & St. Paul and the Chicago, Rock Island & Pacific.

A system of well-graded dirt roads is maintained, and a beginning has been made on road improvement. In 1921, 9 miles of gravel road and 24 miles of permanent concrete road, the latter connecting Hartley and Sheldon, had been completed.

Rural schools are numerous, and there are four consolidated school districts at the present time.

With its eight incorporated towns and six smaller trading centers, O'Brien County is well supplied with local markets. Chicago is the principal outside market for grain, cattle, and sheep, and Sioux City and Chicago for hogs. Some products also are shipped to St. Paul, which is equally as accessible as Chicago and Sioux City.

CLIMATE.

There is no Weather Bureau station in O'Brien County, but the records of the station at Alton, 12 miles west, in Sioux County are believed to be fairly representative of climatic conditions in O'Brien County. These cover the period of 1905 to 1918, and show the mean annual rainfall to be 27.39 inches and the mean annual temperature 45.7° F.

The total rainfall for the driest year of which there is any record (1910) was 17.42 inches, and for the wettest year (1909) 36.48 inches. The records for an average year show the precipitation to be heaviest in May, followed by well-distributed rainfall during the remainder of the growing season. Rains are seldom accompanied by damaging winds or hail, and protracted dry spells are not of common occurrence.

Periods of excessive heat and cold are very seldom of long duration. The maximum temperature recorded is 103° F. and the minimum, −42° F.

The average growing season extends from May 9 to October 1, giving a period of 144 days. The latest recorded killing frost in the spring occurred on May 18, and the earliest in the fall on September 15. The grazing season usually extends from April 15 to about October 15.

The following table gives the normal monthly, seasonal, and annual temperature and precipitation as recorded at Alton, Sioux County:

Normal monthly, seasonal, and annual temperature and precipitation, at Alton, Sioux County.

[Elevation, 1,305 feet.]

Month.	Temperature.			Precipitation.		
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1910).	Total amount for the wettest year (1909).
	°F.	°F.	°F.	Inches.	Inches.	Inches.
December	21.3	56	−34	0.82	0.05	1.90
January	15.2	55	−42	.82	1.45	.95
February	17.7	63	−34	.97	.15	1.65
Winter	18.1	63	−42	2.61	1.65	4.50
March	31.3	86	−20	.92	.02	.92
April	46.8	95	12	2.26	1.25	2.80
May	59.5	95	21	5.12	1.88	4.91
Spring	45.9	95	−20	8.30	3.15	8.63
June	67.7	103	33	3.93	1.26	5.96
July	73.0	103	40	3.42	3.84	6.61
August	71.4	100	33	3.14	4.43	.99
Summer	70.7	103	33	10.49	9.53	13.56
September	62.4	100	20	3.01	2.16	4.42
October	49.0	86	5	1.80	.78	1.43
November	32.6	72	−4	1.18	.15	3.94
Fall	48.0	100	−4	5.99	3.09	9.79
Year	45.7	103	−42	27.39	17.42	36.48

AGRICULTURE.

Settlement of the county, which began about 1856, made slow progress in the following 10 or 15 years. The early settlers located in the extreme southeast corner of Waterman Township, along the Little Sioux River and Waterman Creek, where fuel and game were most available. About 1865 the prairies of western Floyd and Carroll Townships were settled by Hollanders from Sioux County. By 1875 settlers were fairly well distributed over the county. Prairie sod was found to be very difficult to crop for the first few years after breaking. Corn was thought the only crop that could be grown on sod land, and this did very poorly. Wheat was considered the crop best adapted to the region, which was thought to be too far north for good corn yields. According to the earliest unofficial crop reports available, wheat ranked first in 1875, with a reported production of 157,526 bushels; corn second, with 106,052 bushels; oats third, with 53,931 bushels; rye fourth, with 1,281 bushels; and buckwheat fifth, with 200 bushels. The acreage cultivated was reported as 33,626 acres.[1]

Grasshoppers caused many serious crop failures during the years from 1873 to 1878. Relief measures were undertaken by the State with some success. With the exception of these years, crop failures in the county have been negligible.

[1] Baker's History of O'Brien County.

The following statistics concerning farms, farm lands, and crop acreages show the trend of agriculture in the county in the last 40 years.

Statistics concerning farms, farm lands, and the acreages of leading crops, from the census reports of 1880, 1890, 1900, 1910, and 1920.

	1880	1890	1900	1910	1920
Percentage of area of county in farms	20.6	82.1	98.9	95.1	95.8
Number of farms	560.0	1,630	1,845	1,826	1,903
Average size of farms, acres	133.0	185	195.1	189.4	169.3
Percentage of farm land improved	69.1	82.3	95.3	95.3	92.4
Percentage of farms operated by tenants	25.0	30.6	40.5	48.4	56.6
Percentage of improved land in corn	33.0	24.6	29.5	29.8	35.8
Percentage of improved land in wheat	16.5	4.9	10.7	0.2	0.8
Percentage of improved land in hay	13.5	19.8	11.3	15.3	11.4
Percentage of improved land in oats	10.6	16.0	16.5	21.2	27.8
Percentage of improved land in barley	2.0	14.7	10.6	4.2	1.4
Percentage of improved land in flax	.....	9.1	.....	.....	.....

In 1880 the agriculture of the county was still largely of the self-sustaining type; the products were nearly all utilized on the farms, only small quantities being marketed locally.

With the trebling of the population during the decade from 1880 to 1890, the number of farms increased in proportion and the average size increased considerably. There was a marked decline in wheat growing during this period, and a striking increase in the production of oats, barley, and flax. Cereals, vegetables, fruits, nuts, and livestock products were marketed in small quantities locally.

From 1890 to 1900 there was a steady development along all lines, with a considerable increase in acreage in wheat and in the quantity of livestock products marketed. The area included in farms and the acreage of improved farm land reached their maximum about 1900. A considerable acreage was devoted to tame hay, indicating the supplanting of the abundant wild prairie grasses by more desirable cultivated grasses, such as timothy, clover, and millet. Flax, almost exclusively used as a virgin-soil crop, was little grown in 1900.

The total value of farm property per farm increased from $10,395 in 1900 to $22,114 in 1910. While the increase in land values constitutes the largest part of this increase, the value of buildings, implements, and stock increased also. The increase in oats acreage was the greatest, and there was a marked decrease in the acreage and production of barley, and wheat. Tame hay occupied three-fourths of the hay acreage, showing a marked increase over the 1900 acreage. The value of farm products marketed quadrupled between 1900 and 1910. The value of animals sold and slaughtered doubled, and dairy and poultry products trebled. Grains, hay, and forage constituted over half of the value of farm products marketed.

From 1910 to 1920 the improvement of farm land continued, and land values increased greatly. There was also a slight tendency toward smaller farms, and the same steady increase in farm tenancy. Slight increases in corn and oat acreages are the most notable changes in occupation of the land. The farm products marketed in 1919 had twice the value of those marketed in 1909, but this increase is undoubtedly due in large part to the unusually high prices in 1919.

The present agriculture of the county consists chiefly of growing corn, oats, and hay, and raising and fattening hogs for market. Specialized livestock farming, mainly cattle and hog raising, is practiced to a small extent. Dairying and sheep raising are generally side-line activities.

Corn is the most important crop grown. It is the leading cash crop of the county, and in addition ranks with other grains as a subsistence crop. Both the yield per acre and production have increased each census year. In 1920 a production of 5,335,879 bushels was reported, representing a yield per acre of 46.4 bushels. While corn is marketed in larger quantities than other crops, approximately half the production is utilized on the farm in feeding stock. Corn is marketed through the local elevators of the county and in the main consigned to the Chicago market. Seed of mixed home-grown corn is most commonly used. The variety of yellow dent corn locally known as the Armstrong Yellow Dent, which has been grown here for about 30 years, is most popular. White dent varieties are used less extensively, Silver King being planted more extensively than any other variety.

Oats rank second in acreage and production, according to the 1920 census. The crop was 3,659,272 bushels—the largest ever reported by the census. The average yield per acre was 41 bushels. While considerable quantities of oats are marketed, the greater part of the crop is used for feed. It is also regarded as the best small grain to follow corn in a rotation. Mixed varieties are most commonly grown. Early and midseason varieties are about equally popular. Of the early varieties the Kherson and its various strains, Albion, (Iowa No. 103), Richland, (Iowa No. 105), Iowar, and the Early Champion are the most popular. Green Russian is the leading midseason variety. Chicago is the principal market for oats. The crop is moved through local elevators.

Hay and forage crops rank third in acreage. A production of 68,443 tons of hay is reported for 1919, with an average yield of 1¾ tons per acre. Three-fourths of the acreage is in tame grasses and the remainder in wild prairie grasses. Timothy and clover mixed and timothy alone are by far the most important tame hay crops. Alfalfa is receiving increased attention, as, once established, its higher yields per acre, together with its soil improving qualities, constitute marked advantages. According to the census timothy and clover mixed rank second in yield per acre and clover alone third. Year in and year out, however, clover probably outyields the timothy-clover mixture. About one-third of the timothy and clover sown is from home-grown seed. Red clover is the most common strain, with small acreages of mammoth, alsike, and sweet clover. The greater part of the hay crop is fed and the surplus marketed. The local demand is usually supplied, although small quantities are occasionally shipped in.

Millet, sorghum, rape, and soy beans are minor forage and hay crops, utilized as catch crops and in combination seedings for fodder, silage, or green forage.

According to the census, 1,900 acres of silage crops were harvested in 1919, corn occupying practically the whole of this acreage. To a small extent sorghum, and soy beans are used for silage, usually in combination with corn. The average yield of silage in 1919 was 9.9 tons per acre.

Permanent pastures, according to the 1920 census, occupied 21.1 per cent of the improved farm land, or 69,190 acres. The cultivated hay grasses are almost entirely used as the foundation in establishing permanent pastures. Bluegrass is the best established and most common pasture grass.

Barley ranks third among the cereals in extent of acreage in the county. The average yield is about 30 bushels per acre. The crop is grown as a substitute for oats in the rotation. It is used largely as feed for young stock. In some cases it is a cash crop.

Wheat ranks fourth in acreage among the cereals. In 1919 it was grown on 2,463 acres, with an average yield of 13.5 bushels per acre. Spring wheat is the most commonly grown. The crop is marketed locally.

Flax, rye, buckwheat, emmer, and sorghum are crops of minor importance.

Orcharding receives little attention. Apples are the principal fruit grown, Duchess and Wealthy being the most common varieties.

Small fruits and garden crops are produced quite generally in the county for home consumption and in small quantities for local markets. Potatoes occupied 1,002 acres in 1919. Sweet corn and pop corn are planted in small patches on a few farms. Of the small fruits strawberries are most important, followed by raspberries and blackberries.

Hog raising occupies first place among the livestock industries of the county. The census reports 91,358 hogs on farms on January 1, 1920. Of these about one-fourth were brood sows. Most of the herds are of mixed breed, but purebreds are receiving increased attention. The Duroc-Jersey and big-type Poland-China are at present the most popular breeds. The Chester White is raised in considerable numbers. The breeding of Hampshire hogs has increased very rapidly in the last two years (1918 to 1920). Losses from hog cholera are sometimes severe locally. Hogs are shipped principally to Chicago and Sioux City.

The raising of beef cattle is second in importance in the livestock industry. Beef cattle on farms numbered 36,733 in January, 1920. Probably about 10 per cent of these were feeders and the rest were home raised. Most of the cattle are raised on pasturage and roughage and finished at the end of the fattening period on concentrates and roughage. Cattle of mixed breeds predominate, but purebreds are gradually gaining favor. The Shorthorn and Hereford breeds are about equally represented, with Angus less numerous. Beef cattle are marketed principally at Chicago and Sioux City, but some are shipped to St. Paul.

According to the census, dairy cattle in the county numbered 16,030 in January, 1920. About 10,500 of these were milk cows. Four local creameries get their cream mainly from farms in the county. Dairying receives greatest attention in proximity to the local markets, but is nowhere practiced on a large scale. The dairy products in 1919 were valued at $560,050.

The 1920 census reported 14,423 horses and 355 mules in the county. The work horses are of good draft type. Considerable attention is given to the improvement of horses, and annual horse and

colt shows in the county are of State-wide interest. The Percheron, Belgian, Shire, and Clyde breeds rank in popularity about in the order named.

Sheep raising is carried on to a small extent. The 1920 census reported a total of 4,760 sheep. Native sheep are kept largely for wool production, only the surplus young and older stock being marketed. In 1919, 26,378 pounds of wool were produced. The Shropshire breed is the most popular.

Poultry raising is practiced on every farm in the county. According to the census, the chickens and eggs produced in 1919 were valued at $599,490. Practically all poultry products are sold through county marketing agencies.

The soils of O'Brien County are adapted to diversified cropping. The impracticability of utilizing the more rolling areas for cultivated crops is well recognized, and such lands as a general rule are kept in permanent pasture. The heavy-textured soils of imperfect drainage are known to produce a ranker, later maturing growth than the better drained medium-textured soils. Early maturing corn is usually grown on such heavy soils. The growing of oats and small grain is limited because of the tendency of the heavier soils to produce straw at the expense of grain. In wet years the heavier soils produce low yields; and conversely the lighter sandier soils give lower yields in seasons of poorly distributed rainfall. Where the heavy soils are poorly drained, they are commonly used in the production of wild hay. In choosing a soil for alfalfa, the lighter silt loam uplands are preferred to the more compact and poorly drained areas.

While continuous growing of any one crop is not practiced, no fixed system of crop rotation has become established. A few farmers use a rotation consisting of corn 2 years, oats 1 year, timothy and clover 2 years. Corn 1 year instead of 2, wheat or barley in place of oats, and clover alone in place of mixed timothy and clover are variations of this rotation. Alfalfa occasionally takes the place of clover and is grown for 5 to 10 years. Most farmers grow corn and small grain, with only an occasional year of grass intervening.

Corn land is prepared when possible by plowing in the fall and disking and harrowing in the spring. The planting season is from May 1 to 15. Replanting is rarely necessary because of unseasonable rains or insect pests. Where planting is delayed later than about June 10, fodder or silage corn is most commonly planted or a short-season catch crop is grown. Corn for grain is usually check-rowed and silage and fodder corn is usually drilled. When possible, corn is cultivated 4 or 5 times. Quack grass, smartweed, and foxtail are the most common weeds. Canada thistle, ironweed, cocklebur, button weed, corncockle, wild morning-glory, dodder, and beggar's tick are less common, but are sometimes troublesome. Corn is usually harvested from about October 10 to December 15. The practice of selecting seed corn in the field about September 20 is gaining in favor. A small part of the crop is often left for hogging down. Fodder cutting usually starts during the latter half of September. Stalks left in the field are utilized for fall and winter pasturage.

For a second corn crop the land is plowed in the spring. In case a small-grain crop follows, the land is generally disked and harrowed without plowing. Disking and harrowing a number of times is required for the best seed bed. Small grain is either sown broadcast

or drilled. In rotations including grass, the clover or mixed clover and timothy is sown with the small grain. After the grain is harvested, timothy and clover often produces a growth affording light fall pasturage. After cutting the hay the following year, the best practice is to leave the land in sod until the fall, then plow for corn, planting the following spring. Plowing is sometimes delayed until the following spring, but this is not considered good practice. Occasionally the sod is used as the foundation for a permanent pasture of from 2 to 5 years duration.

Alfalfa, when seeded in the spring, usually follows corn, while a fall seeding generally follows small grains.

The buildings on an average farm include a medium-sized hay and horse barn, cattle barn, hog houses of modern type, corncrib, implement shed, and chicken house. According to the census there were 150 silos and 407 tractors in the county in 1919. In unusually productive years crib accomodations are generally inadequate for the corn crop. Field stacking of hay is commonly practiced when the yield is heavy.

The implements in common use include corn planters, gang plows (2 and 3 bottom), 4-section harrows, section disks, 1 or 2 row cultivators, grain elevators (movable or stationary), grain drills and broadcasters, self-binders, mowing machines, dump or side-delivery hayrakes, sweep rakes, hay stackers, mow track, hayfork and slings, fanning mills, and cream separators. Tractors, hay loaders, corn binders, corn pickers, silage cutters, and trucks are somewhat less common. Threshing machines, corn shellers, and grain separators are often cooperatively owned. All fields are inclosed by barbed or woven wire fences. Well water of good quality is available in practically all parts of the county. Windmills or pump engines are in common use.

Manure produced on the farm is practically the only fertilizer used. It is commonly applied on hay or small-grain stubble land preceding a crop of corn, or as a top dressing on pasture land. Commercial fertilizers are used in very small quantities, principally on gardens. Very small quantities of acid phosphate and raw rock phosphate are occasionally used on field crops. Limestone is used in moderate quantities, mainly in preparing acid soils for alfalfa. Only 21 farmers reported an expenditure for fertilizer in 1919. Green manuring is practiced on a small scale, red clover being the crop most commonly grown for that purpose.

The local labor supply is usually adequate, except during corn plowing, small-grain harvesting, and corn husking. All the labor is white and mostly American born. According to the State census the average summer wage for farm labor in 1919 was $58.57 per month, and the monthly winter wage was $34.44. At present (1921), however, wages average $40.96 in summer and $26.20 in winter. Day labor during the 1921 harvest was paid $3 a day. Corn pickers received 4 cents per bushel during the fall of 1921. In addition to wages, all farm labor receives board, lodging, and laundry.

The proportion of tenant farmers has steadily increased in the last 40 years. Some sections, however, notably Caledonia Township, are almost entirely without tenant farms. The conditions of the leases vary widely and change with business conditions. During the war period leases based upon cash rent were the most common. Since then leases on a share basis have been displacing the cash-rent con-

tracts. Hay and pasture lands are usually rented for cash. At the present time (1921) the usual rent for pasture is $6 an acre and for hay land $8 an acre.

Under the share system the owner receives from two-fifths to one-half of the grain crop. The half-and-half basis is perhaps the most common.

The average size of the farms is 160 acres. Farms of this size also are more numerous than those of smaller or larger size. Near towns, where truck growing, poultry raising, and other special interests are more prominent, the number of farms of 80 acres or less is larger. The farms of more than 160 acres generally are not as intensively cultivated as those of smaller size.

SOILS.[2]

Excepting the narrow timber belts along the streams, the soils of O'Brien County in their virgin state were treeless and supported a native vegetation consisting almost wholly of grasses. Under this condition the decay of grass roots has added organic matter to the surface layer of the soil and produced the black color characteristic of all the soils of the area. This is in the form of finely divided carbonaceous material intimately mixed with the mineral constituents of the soil. The incorporation of this organic matter, together with other important soil-forming processes, such as leaching, aeration, and oxidation, which have proceeded under a prairie environment and optimum conditions of moisture and temperature, have imparted to the soils of the area certain definite characteristics. The intensity with which these forces have acted in any given locality and the stage to which the soil has been brought as a consequence, have been determined by local conditions, such as topography and the supply of moisture.

Average drainage conditions determine very largely the proportion of organic matter and the depth to which it has affected the color and other physical properties of the soil. On flats and sloughs this black organic matter extends to depths of 15 to 24 inches, but on the well-drained ridges it is only 8 to 15 inches deep.

On the flats 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 an accumulation of the carbonaceous material 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 filled with organic matter over a gray or mottled calcareous subsoil. Under such conditions the soils of the Webster series have been formed on the flat upland, the Fargo soils on the poorly drained terraces and depressions, and the Lamoure soils on the first bottoms.

Where the land was rolling or for other reasons had better drainage, the conditions were not so favorable to a rank growth of grass or to the formation and accumulation of such large quantities of organic

[2] O'Brien County adjoins Clay County on the east and Sioux County on the west. In certain cases the maps of these counties do not appear to agree along the boundaries. This is mainly due to changes in correlation resulting from a fuller knowledge of the soils of the State. Some of the areas formerly mapped with the Carrington series are now mapped with Clarion soils, and the Shelby with the new Dickinson series. The Lamoure soils are more accurately defined, and their areas now include soils formerly classed with the Wabash series.

matter in the soil. The more vigorous movement of the soil water and better aeration have resulted in the oxidation and leaching of the soil to depths of 3 or 4 feet and in the translocation of the finer particles from the surface foot to the subsoil. We find, therefore, on this topography a dark-brown surface soil, of a depth of 8 to 15 inches, underlain by a brown or yellowish-brown upper subsoil somewhat heavier in texture than the surface soil. This passes into a more friable lower subsoil. The soil section to a depth of more than 3 feet has been leached of carbonates to such an extent that it will no longer effervesce with acid. With this group may be placed the soils of the Carrington and the Dickinson series of the upland and the Waukesha, the O'Neill, and the Judson of the terraces.

Intermediate in its stage of development, between the two groups of soils described above, is a group which covers a greater area than either of them. These soils have developed under conditions of drainage moderately favorable to leaching and oxidation, but these processes have not brought them to the stage of the Carrington group. The result has been the formation of dark-brown to black soils, deeper on an average than the Carrrington soils but shallower than the Webster soils. The upper subsoil has a uniform brown color, a texture heavier than the surface soil, and a lower lime content. The material in the lower part of the 3-foot section, usually below 30 inches, has a brown to gray color, usually a friable structure, and a high lime content. This is the parent material little changed by weathering. The lime is a constituent part of the original parent rock but is localized in some places into nodules. The most important soils in this group are those of the Marshall series. To the group belong also the less extensive areas of Clarion soil in the eastern part of the county and of the Sioux series of the high terraces.

The soils of each of the groups mentioned above are differentiated into soil series on the basis of differences in the 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.

O'Brien County lies within the glaciated section of Iowa and near the western edge of the area overrun by the Wisconsin ice sheet—the last to invade the region. The greater part of the county was later covered by loess or a silty material resembling loess, so that at the present time the coarser Wisconsin drift is exposed only in a nartow strip 1 mile to 7 miles wide along the eastern boundary and in narrow, irregular areas along the deeper stream channels. These two kinds of material are not widely different with respect to their rate of weathering and their capacity to accumulate organic matter. With the exception, therefore, of texture, the principal differences in the soils derived from them have been brought about by the soil-forming processes acting upon them since their deposition.

The loess in its original state was a uniform material, having a yellow or grayish-yellow color and consisting mainly of silt with lesser quantities of clay and fine sand. It is believed that while unleached it contained a large percentage of lime. In the course of its development into a productive soil, there has taken place a partial leaching of lime and other soluble constituents, a slight translocation of clay from the surface soil, an accumulation of black organic matter, and many other changes due to weathering. These processes have

developed the Marshall series of the well-drained and partly leached group and a flat phase of the Marshall silt loam, which shows the effects of less perfect drainage.

The Wisconsin drift was originally a heterogeneous mass of clay, sand, and gravel, having a yellow, buff, or gray color. The composition of the drift in deep exposures, as well as the abundance of limestone bowlders at all depths, indicates that the material was highly calcareous. The soil-forming processes have produced three series of glacial soils, belonging to each of the three important soil groups already described—the Carrington of the well-drained, thoroughly leached group, the Clarion of the moderately leached group, and the Webster of the group characterized by poorly drained and unleached subsoils. In all of these there has been more or less translocation of clay from the surface to the subsoil. The texture of the surface soils appears to vary with the topographic position, the soils of the more rolling Carrington and Clarion series being loams and silt loams, while the poorly drained Webster is a silty clay loam. This is due, at least in part, to the more rapid decomposition of the coarser particles into clay while the soil was in a saturated condition.

The alluvial deposits of O'Brien County are classed in two groups on the basis of age and topographic position, the older high terraces and the flood plains or first bottoms of more recent deposition. Both of these groups have their characteristic soils as determined by the length of time to which they have been exposed to the agencies of weathering.

No extensive areas of terrace have been formed in the county by the present streams, as the valleys are largely constructional and the topography has not favored the formation of broad flood plains, which, after the lowering of the stream level, would be left as bench-like terraces. The most extensive of the elevated terraces were probably deposited by the swollen glacial streams, as they are high above the level of possible deposition by the streams now occupying their valleys. The high terraces are of two kinds, distinguished by differences in their subsoils. One has loose gravelly subsoils, presumably composed of glacial outwash material; the other has clay subsoils and clay substrata extending to a considerable depth. Both types of terraces occupy positions 10 to 50 feet above the stream levels and 25 to 75 feet below the general level of the adjacent upland. As a rule, however, the gravelly terraces stand at higher levels than the heavy-subsoil terraces in any given locality. Two series of soils, the O'Neill and the Sioux, have been developed upon the coarser materials and one series, the Waukesha, upon the heavy-textured deposits.

The first-bottom soils of heavy texture, although they have been developed upon the most recently deposited soil material, occur mainly where the sediments have been laid down in the shallow constructional valleys and along the flood plains of sluggish streams. Along the more rapidly cutting streams, usually having deeper channels, the deposits are of lighter texture and more variable composition. The recently formed alluvial soils are classed according to their lime content into two series, the Wabash and the Lamoure.

The following are brief descriptions of the various soil series as standardized not only for the county but for the general region of their occurrence. These series are divided into soil types on the basis of difference in the texture of the surface soils.

The soils of the Marshall series have dark-brown to black surface soils, moderately soft and friable in structure which are underlain by a gray-tinged yellowish brown, calcareous, heavy silt loam to silty clay loam subsoil. They occupy positions of moderate natural drainage and of undulating to gently rolling topography. The Marshall silt loam and a flat phase of the silt loam are mapped in O'Brien County.

The Clarion series comprises types with dark-brown to black surface soils of mellow structure, underlain by a yellowish-brown silty clay loam or heavy clay loam subsoil containing gray calcareous material in the deeper part. Two types, the silt loam and the loam, steep phase, are mapped. These soils are derived from drift and occur where the deposit of loess is absent or very shallow.

The Carrington series includes mellow surface soils of dark-brown to black color, overlying a light yellowish brown sandy clay to silty clay loam subsoil. These soils differ from the Clarion principally in that the subsoil contains no lime. Only the silt loam type is mapped in this county.

The Webster series comprises almost black, moderately heavy surface soils, generally rich in organic matter, overlying a subsoil of dark yellowish brown, mottled gray, rusty-brown, and yellow, plastic, compact, and poorly oxidized silty clay loam to silty clay. Well-disintegrated calcareous material and some concretionary lime are present in the subsoil. Sand and gravel particles occur in the lower subsoil and in smaller quantities in the surface and subsurface layers. The Webster soils generally occupy nearly level drift plains having poor natural drainage. The silty clay loam type was mapped.

The surface soils of the Dickinson series are dark brown to almost black. They are underlain by brown or yellowish-brown materials which are lighter 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 or sand containing some gravel is encountered. The lower materials are always loose, porous, and somewhat droughty. Neither the soil nor subsoil is calcareous. The series is developed by weathering from a sandy drift. A small area of the fine sandy loam of this series is mapped.

The Fargo series consists of types with almost black surface soils, high in organic matter, overlying a dark yellowish brown and gray mottled subsoil of silty clay loam to silty clay, quite high in lime. They occur chiefly in depressed areas of restricted drainage. These soils are derived from sedimentary material which was washed from the silty soils of adjoining uplands. Only the silty clay loam is mapped.

The Waukesha series includes types with dark-brown to black, mellow surface soils underlain by a light yellowish brown friable silty clay loam subsoil, containing no lime. Only the silt loam type is mapped.

The Judson series comprises dark-brown to almost black surface soils overlying a subsoil of practically the same color and texture and slightly heavier structure. The soil material is only occasionally calcareous. These soils occur on alluvial fans or on colluvial slopes at the foot of bluffs. Only the loam type is mapped.

The O'Neill series consists of dark-brown to black mellow surface soils overlying a subsoil of partly stratified sand and gravel or light sandy gravelly clay loam containing no lime carbonate. These soils occupy outwash terrace positions of marked elevation above present drainage channels. The series is represented by the O'Neill loam.

The types of the Sioux series have dark-brown to black mellow surface soils overlying a calcareous subsoil of partly stratified sand and gravel and light sandy gravelly clay loam. These soils occupy outwash terrace positions and differ from soils of the O'Neill series only in having a calcareous subsoil. The Sioux loam is mapped in this survey.

Soils of recent-alluvial origin occupying first-bottom positions are classified in two series, the Lamoure and the Wabash. The Lamoure series includes dark-colored soils with a heavy mottled subsoil showing a high content of lime. The Lamoure loam and silty clay loam are mapped. The Wabash soils differ from the Lamoure soils mainly in containing no lime carbonate in the subsoil. Two types are mapped in the Wabash series, the loam and the silt loam.

In the following pages the various soils are described in detail. The table below gives the name and the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	262,080	72.8	Wabash loam	4,032	1.1
Flat phase	2,880		Waukesha silt loam	2,176	.6
Clarion silt loam	28,544	7.8	O'Neill loam	1,344	.4
Lamoure silty clay loam	16,832	4.6	Wabash silt loam	1,216	.3
Carrington silt loam	12,032	3.3	Judson loam	960	.3
Webster silty clay loam	11,648	3.2	Sioux loam	512	.2
Clarion loam, steep phase	8,448	2.3	Dickinson fine sandy loam	256	.1
Fargo silty clay loam	6,336	1.7			
Lamoure loam	4,864	1.3	Total	364,160	

MARSHALL SILT LOAM.

The surface soil of the Marshall silt loam is a dark-brown to black mellow silt loam which contains a high percentage of organic matter. This grades at an average depth of 12 to 14 inches into a subsoil of dark yellowish brown, crumbly, heavy silt loam to clay loam which passes at about 20 inches into a light-yellowish or grayish-brown to brownish-yellow heavy plastic silt loam to light silty clay loam of moderately mellow structure and typically high in lime content, in places containing concretionary lime material.

The content of lime in the subsoil is perhaps the most variable characteristic of the type. A number of the more rolling areas where weathering is more advanced have a low lime content, and calcareous material in appreciable quantities is not present until depths of 5 to 10 feet are reached. Such areas quite frequently have a shallower, slightly lighter colored surface soil containing less organic matter, and

a subsurface and subsoil of corresponding lighter color and more compact and brittle structure, usually with a little higher percentage of very fine sand and fine sand in the lower subsoil. This subsoil of low lime content occurs in a few places where the topography is as level and natural surface drainage as poor as on areas having subsoils high in lime. An area of this kind lies in section 5 of Waterman Township; here the surface soil is deep and of dark-brown to black color, the subsurface soil is moderately oxidized, and the subsoil is a heavy clay loam to silty clay loam, moderately plastic and very compact in places, and shows rusty-brown to yellow mottlings in the lower part. A more extensive plain of similar topography and soil profile lies adjacent to the Mill Creek bottoms in sections 3, 10, and 15, Dale Township, and another in section 26, Summitt Township.

In the more rolling areas adjacent to the Floyd and Little Floyd Rivers and over the whole of the areas in Waterman, Liberty, eastern Union, and western Highland Townships and in Grant Township west of Waterman Creek the loess silt loam contains varying amounts of the finer sands. Another variation is found on the elevations in sections 1 and 2 of Floyd Township; here the surface soil is a grayish-brown to dark-brown, mellow, heavy loam to silt loam, which beginning at 10 to 12 inches contains increasing amounts of fine and very fine sand with increasing depth until at 20 to 22 inches the subsoil becomes a light yellowish brown, very compact, friable, loose-structured fine to very fine sandy clay to clay loam. In general, however, the loess is purest in the western part of the county, becoming less pure as one approaches Waterman Creek and the more rolling and well-drained areas in the southern and eastern parts of the county.

The drift mantle underlying the loess material of the Marshall silt loam is evidenced by the presence of appreciable amounts of coarse sand and gravel. The depth to the drift material is variable, but averages more than 24 inches. Where it occurs at an average depth of less than 24 inches, the soil has been mapped as Clarion or Carrington silt loam, the boundaries between these soils being very arbitrarily drawn. Where the surface loess is pure the underlying drift material may not occur in the subsoil and may lie from 5 to 10 feet below the surface. However, where the topography is undulating and depressed the glacial material is reached in scattered places at depths of 32 to 40 inches. Such areas are found in Lincoln and northwestern Center Townships, and in other places in association with the flat phase of the Marshall silt loam, and adjacent to the Clarion, Carrington, and Webster soils in Hartley Township. The undulating land prevailing over the greater part of Baker Township carries a deeper loess mantle, and drift material is present in the subsoil only in a few spots.

The Marshall silt loam is the predominant upland soil over all parts of the county except the extreme eastern part. It has been formed from deposits of fine-textured materials which are commonly supposed to have been transported and laid down by wind action. Since deposition the material has been modified by a slight concentration of clay in the subsoil, the leaching of lime to lower depths, and the accumulation of organic matter in the surface soil.

The topography of the type ranges from undulating to gently rolling and in a few places rolling, but prevailingly it is gently rolling.

Natural drainage is in the main well established, although in gently undulating areas surface drainage is sluggish, while in rolling areas with a soil profile more porous than typical drainage is excessive, resulting in occasional damage from drought.

The Marshall silt loam is the most extensive soil of the county, as well as the most important agriculturally. Practically all the type is in cultivation. About 35 per cent is cropped to corn, and 25 per cent to oats. These constitute the main market crop. Corn is also the principal silage and forage crop used in stock feeding. About one-half of the corn and the greater part of the oats produced is used for feeding stock. Pasture lands, chiefly in bluegrass, timothy, and some native prairie grasses, constitute about 20 per cent and hay lands about 10 per cent of the area. The rest of the type is occupied by farmsteads and by miscellaneous minor crops such as barley, wheat, rye, sorghum, millet, rape, soy beans, buckwheat, flax, and potatoes. Of the hay crops, timothy and clover mixed, timothy alone, clover, and alfalfa rank in importance in the order named.

Corn yields 25 to 75 bushels, or an average of about 45 bushels, per acre; corn for silage, 10 to 14 tons; oats 25 to 55 bushels, averaging about 40 bushels; barley, 25 to 30 bushels; and spring wheat, 15 to 20 bushels per acre. Winter wheat, which is grown to only a small extent, yields about the same as spring wheat. Timothy and clover mixed produces 2 to 2½ tons per acre, timothy alone 1 to 1½ tons, clover alone 2½ tons, and alfalfa 3 to 4 tons per acre. Wild hay acreages on this type are very small.

Ordinarily the Marshall silt loam is maintained in a good state of cultivation with little difficulty. Good natural drainage permits working the soil under a reasonably wide range of moisture conditions. Fall plowing for spring-seeded crops is practiced when possible. Systematic crop rotation is practiced only by a few farmers, the rotation consisting of two years of corn, one of small grain, and one or two years of grass for hay and pasture, or a variation of one year of corn only, and alfalfa for several years in place of two years of clover. All corn and small-grain stubble and late fall hay growth or second-year sod is plowed under. Only occasionally is a crop grown especially for green manure. Most of the farmers vary the corn and small-grain cropping with a grass crop on an average once in seven or eight years.

The barnyard manure is applied most commonly to fields in preparation for corn and to a small extent as top dressing on pastures.

Farms on the Marshall silt loam are well improved as a rule and command under normal market conditions an average price of $250 to $300 an acre, depending upon the improvements and nearness to markets.

Farm practices can be improved along the lines of crop rotation and fertilizing. The prevalence of short-term tenant farming is largely responsible for the existing evils in soil management. Where the system of farm management permits the practice of crop rotation, heavier manuring and occasionally green manuring are recognized as beneficial.

Marshall silt loam, flat phase.—The surface soil of the flat phase of the Marshall silt loam consists of 8 to 10 inches of almost black, heavy silt loam, high in organic matter. The subsoil is a dark-gray to black, heavy, plastic silty clay loam to a depth of 16 to 20 inches

below which it is a grayish-yellow semiplastic to plastic silty clay loam. Below a depth of 30 inches it is faintly mottled with yellowish brown, gray, and rusty brown, and contains lime concretions, but usually calcareous material in abundance is not encountered above the 3-foot depth. Drift material, consisting of coarse sand and gravel, is quite uniformly present below 36 inches.

The soil of the flat phase differs from the typical Marshall silt loam in having a shallower surface silt loam, usually of heavier structure, and a more poorly oxidized and heavier subsoil. The soil of the flat phase closely resembles the Fargo silty clay loam, differing from it only in its silt loam surface soil and its less plastic and better oxidized subsoil. These characteristics and a greater depth to the drift sands and gravel also serve to distinguish it from the Webster silty clay loam. The sand and gravel are present only in the lower subsoil of the flat phase, whereas they occur in the lower subsurface and upper subsoil of the Webster silty clay loam. The boundaries separating the flat phase from these three soil types are usually determined with difficulty and arbitrarily drawn.

The flat phase occurs in Hartley, Center, and Lincoln Townships and in small areas elsewhere in the county. It occupies very gently undulating to level areas, where the weathering of the loess deposit overlying the drift has been slower and less perfect than on the better drained typical Marshall silt loam. Most of the smaller areas occupy slight depressions, while the larger areas in Hartley Township occupy level to very gently sloping tablelands.

The natural drainage, both surface and internal, is inadequate, and tile drainage should be provided.

All of the phase is in cultivation. It originally supported a more abundant growth of prairie grass than the typical Marshall silt loam, and the surface soil has a higher content of organic matter. Under cultivation the same tendency toward rank plant growth exists, consequently the phase is recognized as better for corn and more uncertain for small grains than the typical Marshall silt loam. Pasture and hay acreages also are proportionately larger on the flat phase.

Corn and small grain give lower yields than on the typical Marshall silt loam in wet years and about the same yields in normal seasons. Hay yields are a little higher, and pastures are more easily maintained than on the typical soil.

The soil of the flat phase can not be worked under quite as wide a range of moisture conditions as can the typical Marshall silt loam. Little fertilizer is applied. With adequate artificial drainage and more attention given to the practices of manuring and crop rotation the flat phase should command prices as high as or higher than the typical Marshall silt loam.

CLARION LOAM, STEEP PHASE.

The surface soil of the Clarion loam, steep phase, consists of about 10 inches of dark-brown mellow loam to heavy loam in which the sand particles are mainly of the finer grades. The subsoil is a light-brown to dark-brown heavy loam to clay loam which becomes lighter in color and heavier in texture with increasing depth, and below about 18 to 20 inches is a light to dark yellowish brown to yellow-

brown or grayish-brown coarse clay loam to silty clay loam containing increasing quantities of sand, gravel, and lime concretions with depth. The lime content of the subsoil varies considerably.

This phase is extremely variable in soil-profile characteristics. The surface soil suffers erosion and in any particular area may change in texture with each rain. The substratum of glacial sands and gravels is sometimes exposed, covered by a slope-wash deposit, and again exposed all within a season. It is therefore not surprising to find the surface soil ranging in texture to a clay loam and the subsoil ranging from loose porous sand, gravel, or rock to very compact friable silty clay.

The steep phase of the Clarion loam occurs principally on the slopes along the Little Sioux River and Waterman Creek in Grant and Waterman Townships. Elevations on these slopes range from 50 to 175 feet, and the slopes are in many cases precipitous and terraced by landslides. The topography of the phase is too rolling to permit of cultivation. The run-off is rapid, and erosion is very active and almost impossible to control.

This phase occupies an area of about 12 square miles in the county. It is the only soil on which native tree growth flourished extensively. A few remnants of second-growth forest still stand. Of the native trees the elm, bur oak, basswood, box elder, ash, hard maple, soft maple, wild plum, crab apple, and hawthorn are perhaps the most common. The phase is used only for pasture, which consists mainly of the native prairie grasses. Bluegrass stands are usually sparse, especially during seasons of light rainfall.

Farms on which the phase occurs carry a larger number of grazing stock than those consisting entirely of the silt loam. Cattle and sheep raising receive relatively more attention, and hog raising is not so important. Some dairying is carried on where the areas lie near markets.

The Clarion loam, steep phase, is valued at $75 to $100 an acre; or more when sold with tillable land.

CLARION SILT LOAM.

The surface soil of the Clarion silt loam consists of 12 to 14 inches of dark-brown to black silt loam which is moderately high in organic matter, mellow when dry, and moderately coherent when moist. Below this there is usually a layer of 4 to 6 inches of dark-brown heavy silt loam to silty clay loam which passes at a depth of 16 to 20 inches into light-brown to yellowish or grayish brown silty clay. Rusty-brown, gray, and yellow stains and lime concretions are present in the subsoil and with increasing depth become more pronounced.

Glacial sand and gravel are commonly distributed throughout the subsoil in appreciable quantities. Bowlders are found on the surface and at variable depths in the 3-foot section.

The type occurs in close association with the Marshall and Carrington silt loams, being distinguished from the former by a surface silt loam of less purity and an occurrence of glacial sand and gravel at comparatively shallower depths, and from the latter by the lime content in the subsoil. Small areas of both these types are included

with the Clarion silt loam as mapped. In spots too small to map the subsoil consists of loose gravel. Pits from which this gravel has been excavated are shown on the map by symbols. Areas of the type occurring in close proximity to the Webster silty clay loam have a heavy silt loam surface soil and a more plastic and compact subsoil, which in places approaches the subsoil of the Webster.

The largest areas of the type are in Omega and Hartley Townships. Elsewhere in the county the type is restricted to areas bordering drainage ways, in which the underlying drift material is reached at depths generally no greater than 20 to 24 inches. This development occurs along Mill Creek and its eastern tributaries and to a very small extent along the Floyd and Little Floyd Rivers. The surface soil of areas adjacent to the lower course of Mill Creek in Union Township contains relatively larger proportions of fine sand, a characteristic commonly found where the loess covering is most shallow and impure.

In most cases the Clarion and Carrington silt loams are identical in occurrence. However, where the two adjoin, as along the eastern tributaries of Waterman Creek in Grant Township, the Clarion silt loam occupies slope positions below the higher lying crests and divides of Carrington silt loam. In sections 10 and 11 of the same township the Clarion silt loam occupies an intermediate position between the table-land of Webster silty clay loam and the higher divide of Carrington silt loam. The type is also found on isolated elevations on the Webster silty clay loam table-land in section 23 of Omega Township and in foot-slope positions intermediate between the steep phase of the Clarion loam and the bottom lands in Waterman and Grant Townships.

The prevailing topography of the Clarion silt loam is gently rolling. In Omega Township, adjacent to the Webster silty clay loam, minor areas of the type are very gently sloping to almost level.

Natural drainage is well established, except on the nearly level areas, where the surface and internal drainage is somewhat sluggish. In places along the larger streams the slopes are rather steep and erosion is sometimes severe.

The Clarion silt loam is all in cultivation. Corn, oats, other small grains, and hay rank in the order named. Where whole farms are of this type the cropping practices and systems of farming are similar to those on the Marshall silt loam.

Corn yields 40 to 45 bushels; oats, 35 to 40 bushels; barley, 25 to 30 bushels; winter wheat, 15 to 20 bushels. Alfalfa gives higher yields than the other cultivated hay crops, averaging 3 to 4 tons per acre. It occupies a very small acreage, but its popularity is growing. Clover usually ranks second in point of yield and has about the same acreage as alfalfa. Timothy and clover mixed is most generally grown, the yields averaging about 2 to 2½ tons per acre. Timothy yields 1 to 1½ tons, and wild hay about the same.

The Clarion silt loam can be handled under a reasonably wide range of moisture conditions. The land is usually plowed in the fall for spring seeding. No definite crop rotations are followed, but generally a sod of timothy and clover is turned under about every 7 or 8 years. Cornstalks, small-grain stubble, and the pasture growths are plowed under, but green-manure crops are not grown. Barnyard manure is practically the only form of fertilizer used.

The Clarion silt loam has about the same market value as the Marshall silt loam. The selling price ranges from $225 to $275 an acre, depending upon the improvements, location, and character of other soils included in the farm.

A more definite system of crop rotation is the principal means of improving this soil. The application of large quantities of barnyard manure, the occasional turning under of green-manure crops, and tile drainage in places, would also prove beneficial.

The following table gives the results of mechanical analyses of samples of the soil, subsurface, 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 cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
335039....	Soil, 0 to 12 inches..	0.0	1.2	0.9	5.3	10.4	61.7	20.5
335040....	Subsurface, 12 to 16 inches.....	.4	3.5	3.7	7.9	11.4	56.2	17.0
335041....	Subsoil, 16 to 36 inches.....	1.2	3.5	5.2	12.2	20.6	47.1	10.2

CARRINGTON SILT LOAM.

The Carrington silt loam has a surface soil of dark-brown to black mellow silt loam about 10 to 12 inches deep. The subsoil is a brown to dark-brown, friable, well-oxidized clay loam, which grades at about 18 to 20 inches into a light yellowish brown or light brownish yellow, more compact, but friable, heavy clay loam to silty clay loam containing varying quantities of sand and gravel. In places the lower subsoil is stained with rusty brown, yellow, and gray. The soil and subsoil contain no lime carbonate. Bowlders are rather numerous on the surface and throughout the soil profile.

The type closely resembles the Clarion silt loam, the principal differences being that it contains no lime carbonate and the glacial sands and rocks occur at greater depths. The soil and upper subsoil of the Carrington silt loam closely resemble the Marshall silt loam, but the less calcareous lower subsoil and the presence of glacial sand and gravel at shallower depths serve to distinguish it from that type.

The surface soil of the Carrington silt loam in places varies from heavy loam to heavy silt loam or loam. The lighter textured soil is usually underlain by a more friable subsoil, containing a greater abundance of sand and gravel. Where these coarser materials are present in sufficient quantities the subsoil is a coarse sandy clay to sandy clay loam with a structure approaching in porosity and incoherence the Dickinson subsoil. The heavier surface soil variations are usually underlain by a more uniform textured and heavier subsoil that is less friable and rather compact. The surface and subsurface materials in these places resemble impure loess.

The Carrington silt loam is developed principally in the eastern and southeastern parts of the county, where it occupies an elevated divide east of Waterman Creek, barricading the level plains of the Webster silty clay loam on the east from drainage outlet in that direction. In other parts of the county the type occurs only where erosion has exposed the glacial material.

The topography is gently rolling to rolling, and natural drainage is well established.

All of the type is in cultivation. Corn and oats are the principal crops; barley and wheat are of minor importance. Corn is not grown as continuously as on the Webster silty clay loam and crop rotations are more commonly practiced, with the result that small grains and timothy and clover are more extensively grown. The larger pastures on the type occur in association with the steep phase of the Clarion loam in Grant and Waterman Townships.

Crop yields and farm practices are the same as on the Clarion silt loam. The Carrington silt loam possesses the same structural and moisture conditions as the Clarion silt loam, and practices recommended for the Clarion silt loam apply equally to this type. Improved land of this type sells for $200 to $300 an acre.

WEBSTER SILTY CLAY LOAM.

The surface soil of the Webster silty clay loam has an average depth of 10 inches and is an almost black silty clay loam high in organic matter and quite plastic when moist. The subsurface layer is a dark grayish brown to black, heavy silty clay loam to silty clay, which at 20 inches becomes slightly mottled and more plastic. The subsoil, which in most areas appears at a depth of 20 inches, is a yellowish-brown plastic silty clay, heavily mottled with gray and rusty brown, and contains lime concretions or calcareous material in varying quantities. Sand and gravel are present in the subsoil, but seldom modify its tenacious structure. A few bowlders are on the surface and in the soil.

Where the Webster silty clay loam is closely associated with the Clarion and Carrington silt loams the subsurface layer consists of well-oxidized yellow-brown silty clay loam. Areas of Clarion and Carrington silt loam too small to map are included in the Webster silty clay loam. In some places the surface soil contains an unusually large percentage of coarse sand and approaches a clay loam or extremely heavy coarse loam in texture.

The principal area of the Webster silty clay loam in this county lies along the eastern boundary, where it adjoins a wide, unbroken plain of this soil in Clay County. Elsewhere in O'Brien County the areas are relatively small and scattered. This soil has been formed from the most uniform and finest textured material deposited by the glacier on level plains, where conditions for thorough weathering have not been developed. The main modifications since deposition have been the concentration of clay in the subsoil and the accumulation of organic matter in the soil. In the smaller areas in the central and northwestern parts of the county the surface material may be in part of loessial origin.

The type has an undulating to level topography and occupies continuous table-land positions or smaller depressed areas in sections where the Marshall silt loam predominates. Natural drainage has not as yet dissected its level surface, and internal drainage through the heavy, compact subsoil is usually sluggish.

The Webster silty clay loam has a total area of about 19 square miles and is of considerable importance agriculturally. It is one of the most fertile soils in the county. Pasture and hay lands occupy a larger proportion of this type than of the Marshall silt loam. Corn

is grown to a greater extent than the small grains. Of the small grains, oats are most commonly grown, barley and wheat ranking next in acreage. Timothy and clover mixed, timothy alone, and clover and alfalfa on very small acreages are the cultivated hay crops. Wild hay occupies only the poorly drained, water-logged spots. Bluegrass does excellently on the type. Short-season hay and forage crops, such as millet, sorghum, rape, rye, and buckwheat, are grown occasionally as catch crops.

Crop yields vary with the drainage. On well-drained areas, corn yields 50 to 60 bushels per acre and oats 35 to 40 bushels, timothy and clover will yield about 2 to 2½ tons per acre, timothy alone 2 tons, clover alone 2½ tons. Alfalfa, when established on well-drained areas of the type, outyields any other tame hay, but at present very little of it is grown.

Most of this type requires tile drainage for successful grain cropping. After drainage is installed, small grains and flax are grown the first year or two. Following this conditioning period, the soil is less refractory and in good condition for corn growing. The type is used more continuously for corn, to the exclusion of small grains and hay, than the Marshall silt loam. The more progressive farmers practice some form of crop rotation, however, usually corn 2 years, small grains 1 year, and grass 1 or 2 years. Manure is not applied with any regularity.

It is well recognized that the soil is apt to clod if plowed when too moist. Usually plowing must be delayed longer in the spring than on the silt loam upland types, and therefore fall plowing is more generally practiced. Frequent cultivation is required to prevent baking and cracking of the surface. The selection of early-maturing varieties of grain is receiving more attention, owing to the tendency toward rank growth and late maturity on the type.

In its present unimproved state the Webster silty clay loam commands lower prices than the silt loam upland soils, but well-drained areas are valued as high or higher in some cases. Prices range from $175 to $300 an acre, depending principally upon the state of improvement. The drainage and the physical structure of the soil can be improved by the installation of tile drainage, fall plowing, thorough cultivation, and the turning under of barnyard and green manures

DICKINSON FINE SANDY LOAM.

The Dickinson fine sandy loam has a surface soil of dark-brown moderately loose fine sandy loam to light loam, which extends to an average depth of 14 to 16 inches without appreciable change. When moist the surface soil has considerable body, but when dry it is loose and porous. The subsoil is a light yellowish brown very light sandy clay to heavy sandy clay loam which has a loose structure under all moisture conditions. The sand is predominantly fine, although occasionally gravel is found, especially in the lower subsoil at 30 to 36 inches. Usually the subsoil becomes more porous and loose and lighter in texture with increasing depth, and in places approximates a sand or light sandy loam.

The Dickinson fine sandy loam occurs mainly as small areas capping the upland slopes adjacent to Mill Creek in Dale and Union Townships. Other areas too small to map lie in similar positions

within the areas of the Clarion loam, steep phase, along Waterman Creek and Little Sioux River. Two small areas in section 7, Union Township, and section 23, Caledonia Township, occupy low hill positions standing out prominently from the surrounding uplands. Here the subsoil consists mainly of coarse sand and gravel.

Owing to its rolling topography and its position near drainage ways, this type has very efficient surface drainage, the run-off in places causing erosion of the surface soil. The internal drainage is also thorough, owing to the porosity of the subsoil. In periods of low rainfall crops suffer from drought.

The type is unimportant agriculturally because of its small extent. Most of it is used for pasture or hay land and a small part is cultivated to corn and small grain. Pastures usually suffer during the driest periods of the grazing season and hay yields are low. Where cropping is practiced, rotation of the grains with grasses, the application of manure, and occasionally green manuring are essential for best returns. The yields are about the same as those obtained on the O'Neill loam and Sioux loam. No fair valuation can be made of the soil as it occurs in O'Brien County on account of its small extent, but it is generally considered of lower value than the associated Carrington and Clarion soils.

Below are given the results of mechanical analyses of samples of the soil and subsoil of the Dickinson fine sandy loam:

Mechanical analyses of Dickinson fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
335037....	Soil, 0 to 16 inches..	2.1	9.4	9.3	40.8	12.9	17.3	8.0
335038....	Subsoil, 16 to 36 inches.	3.9	15.6	14.2	37.4	9.4	13.5	5.8

FARGO SILTY CLAY LOAM.

The surface soil of the Fargo silty clay loam consists of 14 inches of almost black silty clay loam, high in organic matter, retentive of moisture, and somewhat plastic. The subsoil is a light to dark grayish brown, heavy, moderately plastic silty clay loam to silty clay, which becomes more poorly oxidized with increasing depth and at an average depth of 26 to 30 inches shows prominent mottlings of yellow, brown, gray, and rusty brown. The subsoil is high in lime, which in places is present in the form of concretions. The type closely resembles the Webster silty clay loam, but does not contain any appreciable quantities of glacial sand and gravel or bowlders. It differs from the Lamoure silty clay loam in that it is not subject to intermittent ponding or overflow.

The Fargo silty clay loam occupies three distinct drainage positions: (1) It occurs most commonly as depressed areas in the upland at the immediate head of drainage ways or as low flat divides between drainage ways. Such a development is found in section 20 of Hartley Township. (2) It occupies gentle foot-slope positions adjacent to the broader and shallower upland drains. The areas in sections 24 and 25, Hartley Township, are of this kind. (3) A few areas occupy ter-

race positions intermediate between the bottom lands and uplands. These terrace formations were formerly glacial stream or lake beds, as shown by the presence of a uniform gravel substratum. The heavy soil material may in this case have been deposited by water at the time of the glacial deposition of the underlying gravel.

The topography of the Fargo silty clay loam is generally flat, but in depressed areas it is very gently sloping. The natural surface drainage is restricted and the internal drainage is very sluggish, consequently the soil is intermittently or permanently saturated, except where the land is artificially drained.

The Fargo silty clay loam, owing to its moderate extent, is relatively unimportant in the county. The original growth of wild prairie and slough grass is still found on such areas as are in almost a permanent state of saturation. Over most of the type the drainage conditions have not been improved sufficiently for cropping, but the periods of saturation are only intermittent. About half the type is in pasture and the rest is in cultivated hay, wild hay, and grain crops. All of the type is put to some agricultural use. Of the grain crops corn ranks first and oats second. Corn yields better in dry years. Small grains suffer more than corn in wet seasons, owing to the rank growth and tendency to lodge. Timothy and clover mixed is the leading hay crop. In case of corn failure, short-season hay or forage crops are sometimes sown, such as millet, rape, Sudan grass, and sorghum. Where the acreage of this type in pasture is large considerable stock is kept, but where the type is cropped the tendency is toward grain farming.

Corn yields 25 to 60 bushels per acre, averaging about 40 bushels; oats, 20 to 45 bushels, with an average yield of 35 bushels; timothy and clover mixed, yield 2¼ to 2½ tons; timothy alone, about 2 tons; and wild hay, 1½ to 2 tons per acre.

Poor drainage is the limiting factor in crop production on this type. The soil should be worked only when the moisture conditions are right, as it has a tendency to clod and bake. Heavy cropping is practiced on the most improved areas, and little fertilizer is applied, except for the purpose of improving the physical structure of the soil. From one to three years are usually required before newly broken land of this type is tractable and in condition for successful cropping. During this conditioning period flax and small grains are usually grown.

Land values range from $80 to $250 an acre, according to the state of improvement, the average being about $175.

Drainage improvement is essential to the best crop yields on this type. The maintenance of fertility is not an immediate problem, but the turning under of barnyard or green manure improves the soil. The presence of surface alkali is sometimes a special problem. This condition is more prevalent on the Lamoure silty clay loam, however, and the remedial practices recommended for that type apply also to this soil.

WAUKESHA SILT LOAM.

The surface soil of the Waukesha silt loam is a dark-brown to black silt loam, with variable small percentages of fine and very fine sand. It is mellow when moist and crumbly when dry. This material grades at an average depth of 14 inches into lighter brown to yellowish-brown

or pale-yellow clay loam to silty clay loam containing variable but somewhat larger percentages of fine sand than the surface soil. The subsoil becomes increasingly compact with depth and is only moderately plastic. The type is quite uniformly lacking in lime carbonate.

The most common variation includes areas in which a loose-structured coarse sandy or gravelly loam is encountered in the lower subsoil at a depth of about 32 to 34 inches. This variation occurs chiefly on the eroded terrace slopes to the adjacent bottom land, and, in some places, as in section 11, Union Township, is sufficiently extensive to be mapped separately as O'Neill loam. Terraces of this type along the upper course of Waterman Creek and along Little Waterman Creek show evidences of this gravelly material in the lower subsoil and substratum. Commonly associated with these more gravelly subsoils is a surface soil of heavy loam. The areas of most variable surface texture are along the lower course of Waterman Creek, where they receive material washed from the higher slopes. Included with this soil as mapped are also small areas of Fargo silt loam and silty clay loam too small to map. Such spots occur most commonly on the lowest lying and most poorly drained terraces or in poorly drained spots at the foot of the upland slopes.

The Waukesha silt loam occupies small benchlike terraces along practically all the main drainage courses of the county, except the Ocheyedan and Little Sioux Rivers. In the deeper valleys the terraces lie at elevations of 15 to 30 feet above the bottoms, while in places along streams of slight dissection the benches are only 5 to 10 feet above the first bottoms. The largest area, containing about 300 acres, lies in section 11 of Union Township on a terrace 15 to 20 feet above Dry Run. A few small areas in section 32, Summitt Township, sections 2 and 3, Carroll Township, and section 10, Floyd Township, are surrounded by first bottoms.

Owing to the level, benchlike topography, the natural surface drainage of the type is poor, but the proximity of main drainage ways and the friable structured subsoil and substratum combine to effect well-regulated underdrainage. In places where the loose gravel substratum is of considerable depth the internal drainage is even excessive in times of low rainfall.

The Waukesha silt loam, while inextensive, is all in agricultural use. Over half of the type is devoted to grain growing and the rest to the producing of hay and pasturage. The grain crops are corn, oats, and barley, named in order of importance. The hay acreage is mainly timothy and red clover, with smaller acreages of alfalfa, clover alone, and native prairie grasses. Many of the smaller areas of the type are included in permanent pastures maintained on the adjacent bottom lands.

Farming methods and crop yields on this type are about the same as on the Marshall silt loam. A larger proportion of the Waukesha silt loam is cultivated, however, owing to its more level topography. The type is valued as high as the Marshall soils, but prices are influenced by the proximity of bottom lands of lower value.

O'NEILL LOAM.

The O'Neill loam consists of a dark-brown to black loam to heavy loam, with an average depth of 10 to12 inches, underlain to a depth of about 20 inches by a yellowish-brown heavy loam to clay loam, in

places moderately compact, and below this by a yellowish-brown to brownish-yellow sandy loam to coarse sandy loam or gravelly loam, of loose, porous structure, with interbedded layers of slightly stratified sand and gravel. No calcareous material is found in the soil section. In a few places the layer of heavier material is thicker than 20 inches, but in many more the gravelly sandy subsoil is reached at shallower depths and may appear at 10 inches below the surface. In places the subsoil consists of very loose sand and gravel, quite well stratified, and extends to considerable depths. Gravel-pit excavations have been made at many such places.

The O'Neill loam occupies outwash terraces adjacent to the bottoms of the Ocheyedan and Little Sioux Rivers and the lower courses of Waterman and Mill Creeks. Individual areas of the type are usually inextensive; the largest single occurrence of the type is along the Ocheyedan River, in Hartley Township. The terraces occupied by the type usually lie about 25 feet above the bottoms. In section 24 of Waterman Township the terrace is about 50 feet above the river bottom, while in section 29, Omega Township, along the upper course of Waterman Creek, a terrace of O'Neill loam has an elevation of only 5 to 8 feet. In section 11, Union Township, the main terrace formation has a heavy subsoil, but along the terrace bluffs there is an occurrence of loose sand and gravel at subsoil depths.

These remnant terraces are level, and rarely dissected by drainage issuing from the uplands. Owing to the loose, porous subsoil, internal drainage is thorough to excessive, and in periods of light rainfall crops are likely to suffer from drought.

The O'Neill loam is inextensive and is not important agriculturally. All of it is in use, but it is recognized as inferior to the heavier subsoil types for cropping. Over half of the type is in pasture and hay land. Corn is the leading cultivated crop, followed by small grains. Crop yields vary considerably with seasonal conditions. In dry years corn yields as much as 20 bushels per acre lower than in seasons of well-distributed rainfall. On the average, corn yields about 30 bushels per acre, oats 25 to 30 bushels, and timothy and clover hay 1½ tons per acre.

The O'Neill loam is well adapted to farming. It is level, with practically no waste areas, and can be handled under a wide range of moisture conditions. Its lack of organic matter is recognized, and cropping is less continuous than on other soils of the county and applications of manure are heavier.

From $125 to $175 is perhaps a fair estimate of the type's market value under normal conditions.

Manuring, to increase the supply of organic matter and to improve the moisture-holding power of the soil, is the main soil-improvement practice to be recommended.

SIOUX LOAM.

The surface soil of the Sioux loam is a dark-brown to black mellow loam to heavy loam. This is underlain, usually at a depth of 10 to 12 inches, by a light-yellowish, brown, or grayish-yellow loam to fine sandy loam or sandy loam, of loose structure and moderate lime carbonate content. At a depth of about 20 inches the sand particles become coarser and more abundant, giving to the subsoil a loose por-

ous structure and a texture varying from a fairly uniform fine sandy loam to a sandy or gravelly loam, lacking uniformity and generally slightly stratified. The subsurface in almost all areas effervesces with acid and the subsoil everywhere is calcareous. Where the type is associated closely with the O'Neill loam the presence of lime is less noticeable.

As mapped the Sioux loam is restricted to terrace positions adjacent to Waterman Creek in Grant and Waterman Townships.

The areas in sections 4, 22, and 34 of Grant Township occupy higher terraces than other areas of the type. These terraces, though apparently of older formation than other Sioux terraces, still contain lime in appreciable quantities. The area in section 34 of Grant Township is of the same elevation as the O'Neill loam to the east; its more restricted drainage owing to its position at the foot of the upland bluff accounts for the presence of lime.

The Sioux loam has a level, practically undissected topography, and the surface drainage is therefore somewhat slow. The underdrainage, while less active than that of the higher lying O'Neill loam, is excessive, the type being droughty in periods of light rainfall.

This is an unimportant type in O'Brien County. Its main use is as hay and pasture land, only about one-fourth of the type being cropped to grain. Crops and yields are practically the same as on the O'Neill loam. The two types have about the same market value. From $125 to $175 an acre is a fair average market price under normal conditions. Soil-improvement methods suggested for the O'Neill loam apply equally as well to the Sioux loam.

JUDSON LOAM.

The Judson loam consists of a dark-brown to almost black mellow loam to heavy loam, high in organic matter, extending to a depth of 10 inches, where it grades into a dark-brown to black material of the same texture, but slightly more compact than the surface soil. Below an average depth of 20 inches the subsoil is a dark-brown moderately plastic loam, and contains a greater abundance of fine sand than the overlying soil material. Small quantities of lime carbonate are present throughout the soil section in places.

The areas of the type in the northeast quarter of section 27, Grant Township, and in sections 14 and 23, Waterman Township, conform to the above description. In general, the type is rather variable; the surface soil ranges from fine sandy loam to heavy loam and is sometimes subject to slight annual change from slope-wash material and deposits by freshets. Thin layers of loose sand of varying grades are encountered locally in the subsoil. Small areas of Sioux and O'Neill loam are included with the type as mapped.

The Judson loam is mapped only in Grant and Waterman Townships, in the valleys of Waterman Creek and Little Sioux River. Typically it occupies slope-wash positions at the foot of the steep upland bluffs bordering the valleys, as in section 34 in the Little Sioux River Valley. Other areas of similar position consist of narrow strips adjacent to the bluffs. In a few places, as in sections 22, 27, and 34, Grant Township, the type occupies terrace positions and receives slight deposits from freshets, resulting in a soil equally as variable as the slope-wash material.

The topography is gently to very gently sloping in slope-wash positions, and level to gently undulating in the terrace positions. In the former surface drainage is better established than in the latter, while underdrainage is well established.

Though of minor extent, the Judson loam is quite heavily cropped and its productiveness is generally recognized. Corn, the leading crop yeilds about 50 to 60 bushels per acre. Small grains are of minor importance, owing to the tendency of the soil to produce heavy straw at the expense of grain. Some of the type is in grass, but very little of it is permanently maintained as pasture. The type does not occur on any farm to such an extent as to influence the cultural methods, but its presence usually increases the value of the farm.

The soil-improvement practices recommended for the Marshall silt loam apply equally well to the Judson loam.

LAMOURE LOAM.

The surface soil of the Lamoure loam is a dark-brown to black, light to heavy, mellow loam, which contains considerable fine sand, is slightly plastic when moist, and of moderately loose structure when dry. At a depth of 16 inches this grades into a dark grayish brown to black heavy loam to light silt loam with a variable content of sand. Calcareous material is not present in such abundance as in the Lamoure silty clay loam.

Several variations of the type are included. In the valley of Waterman Creek, in Omega, Grant, and Waterman Townships, the surface texture ranges from a fine sandy loam to heavy loam. Occasional shallow layers of loose sand are encountered at varying depths. The deeper subsoil material may be a rather plastic heavy silt loam to silty clay loam, as in sections 25 and 36 of Union Township, and along the lower course of the Floyd River.

The most extensive areas of Lamoure loam are along Waterman and Willow Creeks and the Floyd and Little Floyd Rivers. The type occupies bottom lands very similar to those of the Wabash loam. The traversing streams usually have moderate fall and comparatively deep channels. The Lamoure loam bottoms are subject to annual overflow, the variable character of the deposits rendering the surface texture of the type very changeable. Local slope wash constitutes another variation, especially in the gorgelike valley of Waterman Creek. Probably the most uniform soil is in the area at the confluence of Nelson and Willow Creeks in sections 25 and 36 of Union Township, where the type occupies a constructional valley too large to be modified by floods from the small streams traversing it.

The topography of the Lamoure loam is level, except for ridges and depressions formed by erosion and deposition during floods. The type is well drained, except where it occupies a constructional valley position as in section 25, Union Township.

The Lamoure loam is an important bottom-land type. It is devoted to pasture and hay land in the main, even less of the type being used for grains than of the Wabash loam. Bluegrass maintains a good stand even in times of low rainfall, though not as good as on the silty clay loam.

Corn is the principal cultivated crop, the small grains ranking second. Crop yields are practically the same as on the Wabash loam.

Owing to its light texture and structure, the type can be worked with greater ease and under a wider range of moisture conditions than the silty clay loam, and it is seldom intractable after the first season of cropping. Only small areas of the type not exposed to damaging overflows are cropped. Little fertilizer is used. The natural fertility of the soil has been little depleted in the comparatively short period during which the type has been under cultivation.

The valuation of the Lamoure loam is practically the same as that of the closely related Lamoure silty clay loam and Wabash loam.

Drainage and protection from overflow are the first requisites for improving the type where the areas are large enough to justify the cost of such improvements. Manuring and a system of crop rotation should be practiced to maintain productiveness.

Several areas of Lamoure silt loam have been included with the Lamoure loam because of their small extent. The surface soil of the former consists of 14 to 16 inches of an almost black light to heavy silt loam. The subsoil is a dark-brown to black heavy clay loam to a depth of about 24 inches, where it grades into a dark grayish brown to black, heavy, plastic silty clay loam to silty clay, slightly mottled with yellow, brown, and gray. The subsoil, and in places the surface soil, is calcareous.

The Lamoure silt loam typically occupies down-stream positions adjoining the silty clay loam, as in Grant Township along Jordan Creek and in Hartley Township along Waterman Creek. An area in section 20, Union Township, occupies a slightly higher position back from the Wabash loam bordering the stream channel.

LAMOURE SILTY CLAY LOAM.

The surface soil of the Lamoure silty clay loam is an almost black moderately plastic to plastic silty clay loam to silty clay, high in organic matter. This is underlain at an average depth of 16 to 18 inches by a dark-brown to black, plastic, poorly oxidized silty clay, which in the lower subsoil is faintly to heavily mottled with yellow, brown, and gray. The subsoil is highly calcareous and the surface soil is slightly calcareous in places.

Locally, at depths ranging from 24 to 36 inches, there is coarse sand and gravel, in places quite loose but commonly containing sufficient clay and silt to cause a moderate degree of plasticity when wet. Such material underlies most of the type in the Ocheyedan River Valley and the upper course of Waterman Creek in Lincoln Township, but is elsewhere of spotted occurrence. In the Ocheyedan River Valley this gravelly material is encountered only in spots in the subsoil, but appears rather generally at depths of 5 to 10 feet. There is also considerable variation in the texture of the surface soil. Adjacent to other bottom types or in narrow upland swales that receive slope-wash material, the texture may approach a loam on the one hand or a silty clay on the other. Boundaries in such cases are quite arbitrary.

The largest areas of Lamoure silty clay loam are in the Ocheyedan and Floyd River Valleys. Elsewhere in the county the type occurs in narrow valleys and depressed upland swales or former ponded areas in which there is now sluggish natural drainage. In general, the

extreme upper courses of the drainage ways have bottom lands of Lamoure silty clay loam, which lands represent the most recent alluvial deposits of the county. The deposits in the Ocheyedan and Floyd River valleys probably were not built up by the comparatively small streams now traversing them. Undoubtedly these constructional valleys were molded by glacial agencies and have evolved from glacial lakes through a quagmire stage to their present state of drainage[3], under which the fine-textured surface materials were deposited.

In its larger areas the Lamoure silty clay loam has a level surface broken only by abandoned stream channels. At the heads of drainage ways in the uplands the type occupies the base of troughlike depressions.

The natural drainage of the type as a whole is very poor. The areas are subject to frequent overflow and owing to the heavy subsoil the surface is almost continuously water-logged. Except in the Ocheyedan River valley, where the stream channel has been dredged and straightened to prevent overflow, crops are very uncertain.

Although most of the individual areas of the Lamoure silty clay loam are not large, the general distribution of the type over the county makes it of considerable importance. Pastures occupy about 65 to 70 per cent of the type, tame and wild hay land 20 to 25 per cent, and grain crops the remainder. Where the land has been drained and protected from overflow it is used for cultivated crops. Corn gives the best results and is most commonly grown. Oats and other small grains suffer frequently from lodging, owing to the tendency toward rank stalk growth. Tame hay gives high yields and wild hay and pasture stands are well maintained. Bluegrass does well even during periods of light rainfall. Corn on well-drained land yields 45 to 55 bushels per acre, oats 25 to 35 bushels, timothy and clover 2¼ to 2½ tons, and timothy alone 2 tons per acre. The wild grasses yield about 1½ to 2 tons of hay per acre.

The Lamoure silty clay loam can not be worked successfully under a very wide range of moisture conditions, and seed-bed preparation is sometimes retarded. Because of this and the tendency of grains to produce a rank growth and mature late, special attention is given to selection of early maturing varieties. Tile drainage has been installed in a number of areas. Manure is used to a small extent to improve the physical structure of the heavy surface soil. Fall plowing is more commonly practiced than spring plowing, and usually results in a better seed bed. For the first two years after reclamation the soil is usually intractable. Flax, potatoes, or small grains are grown during this period, after which corn is grown to a large extent. The type is more continuously cropped to corn than the Marshall soils.

There is a wide range in value of the type. Pasture land sells for $75 to $100 an acre; cultivable land has about the same value as the Marshall silt loam.

Improved drainage is the greatest need of the Lamoure silty clay loam. The presence of alkali in spots is a special problem in some cases. According to the Iowa Agricultural Experiment Station, such a condition, where not too severe, can readily be remedied by thorough underdrainage with tile and liberal applications of manure and straw

[3] T. H. McBride, Geology of Osceola and Dickinson County, p. 477.

to give the surface soil more porosity. Continuous cropping without addition of manure will sooner or later deplete the soil of its naturally high fertility.

WABASH LOAM.

The surface soil of the Wabash loam is a dark-brown to black, light to heavy, mellow loam, with a variable content of sand. Below a depth of 14 inches the material is usually slightly more compact and in places somewhat heavier in texture; when moist this is moderately plastic and when dry quite friable. With increasing depth the material becomes slightly lighter in color, and the lower subsoil locally contains mottlings of yellowish brown and rusty brown. Both soil and subsoil are well leached and low in lime.

Owing to its first-bottom position the soil profile shows considerable variation from the periodic deposition of transported materials. The soil profile is fairly uniform in the broader bottoms and has the greatest range of variation in the narrower valleys along the swifter streams. Shallow layers of loose fine sand to sandy loam are found at all depths in the profile, and the texture of the surface soil varies from a light sandy loam to heavy loam. In the more extensive areas the surface soil approaches in places a silt loam, and the subsoil is heavier in texture, more compact in structure, and less thoroughly oxidized, as shown by profuse mottling of yellowish brown and rusty brown. The type includes areas of Lamoure soils too small to show separately on the map.

The Wabash loam occurs as continuous bottom land along Mill Creek to the fork of Dry Run in Dale Township and as rather extensive areas along its tributaries. The bottom soils along Little Sioux River and Waterman Creek in its lower course are largely of this type. The type is developed in bottoms traversed by streams of moderately swift currents. The soil has been leached of lime carbonate. At present it is subject to only short annual overflows.

Except for the ridges resulting from abandoned channels and overflow deposition the topography is level. The natural drainage is perhaps better than on the other bottom lands of the county. A friable subsoil and a moderately deep water table insure fairly good underdrainage.

Practically all the Wabash loam is put to agricultural use, but as the type is subject to periodic overflow, it is chiefly utilized as pasture land. Areas of higher elevation along the Little Sioux River and Mill Creek are cropped, principally to corn. Small grains and tame hay are of minor importance. Bluegrass is the main permanent pasture grass.

The overflows are not sufficiently prolonged to injure pasture grasses, and owing to favorable moisture conditions at other times pastures are maintained in good condition through longer periods of light rainfall than in the uplands. Prairie or slough grasses make good growth, and yield both hay and pasturage.

Corn yields exceptionally well on the type, averaging 45 to 60 bushels per acre. Small grains have a tendency to produce straw at the expense of grain, and losses from lodging are quite common. Oats, the most common small grain, yield from 25 to 40 bushels per acre; timothy alone, 1½ tons to 2 tons, and timothy and clover mixed, about 2 to 2½ tons of hay per acre.

The Wabash loam is recognized as a very productive and easily managed soil, but owing to overflows most of the type is suited only for pasture. Because of the good internal drainage the soil is usually well aerated. Good seed beds are easily obtained, and the type can be worked under a wider range of moisture conditions than the heavier bottom soils. Manuring is not practiced to any extent.

Fair valuation of the Wabash loam is difficult. Where it is included in farms, with cultivable soils comprising the greater part of the acreage, the Wabash loam does not detract from the farm's value, but where it comprises the greater part of a farm the value is usually lowered. Under normal market conditions the type would probably bring $75 or more for pasture land, and two or three times as much for well-improved cultivable land. The average value is perhaps less than that of the Lamoure silty clay loam.

In its present state the Wabash loam is best utilized for pastures. Diking might be practicable in improving the larger areas of the type for cultivation. Under continuous cropping the soil will eventually need manure or some other fertilizer to maintain its productiveness.

WABASH SILT LOAM.

The Wabash silt loam has a surface soil of dark-brown to almost black light to heavy silt loam containing considerable organic matter. This passes at an average depth of 10 inches into a dark grayish brown heavy loam to light silt loam containing variable amounts of fine sand, which extends to a depth of about 16 to 18 inches. The subsoil is a dark-brown to black rather plastic, heavy silt loam to light silty clay loam which, with increasing depth, becomes slightly more plastic, and in the extreme lower subsoil is faintly mottled with yellowish brown and rusty brown. Calcareous material has been practically all leached from both the surface soil and the subsoil. In the areas of poorest drainage the lighter textured subsurface layer is usually absent and the subsoil has greater plasticity, poorer oxidation, heavier staining of yellowish brown, gray, and rusty brown, and a texture approaching a silty clay loam or silty clay. Such a profile is of general occurrence in the area in the Ocheyedan River bottom. Variable amounts of sand are also found throughout the soil profile, as in the Wabash loam, but not to so great an extent.

The type has its largest development in the Ocheyedan and Little Sioux River bottoms and the lower Waterman Creek valley. In the valleys of the Little Sioux River and Waterman Creek the areas lie at a distance from the channel, where the more slugglish overflow waters have deposited the silt loam. A few areas of the type are subject to occasional overflows of short duration. Where the type adjoins areas of Judson silt loam the soil is locally modified by slope-wash material and the boundaries between the two types are arbitrary. The area in the Ocheyedan River bottom occupies a strip adjacent to the channel, where the heavy silty clay loam deposited so uniformly over the remainder of the bottom has been more recently modified by lighter textured surface materials.

The topography is level, except for a few slight ridges remaining from the activity of old channels. The natural drainage is moderately well developed, largely through underdrainage. Artificial drainage is usually necessary for best results with crops.

The Wabash silt loam occupies only a small area in the county, but all of it is put to agricultural use. While pastures occupy the greater part of the type, the acreage of grains is relatively greater than on the Wabash loam. When not damaged by overflows crops yield remarkably well, corn averaging 50 to 55 bushels per acre, and oats 25 to 35 bushels per acre. Stalk growth is usually rank, and lodging frequently reduces the yields of small grains. Hay yields are about the same as on the Wabash loam. The Wabash silt loam is handled in much the same way as the Wabash loam, though owing to inferior underdrainage the silt loam can not be worked under as wide a range of moisture conditions as the loam. Ordinarily there is little difficulty in preparing a seed bed on the silt loam type. Very little manure is used. The measures suggested for the improvement of the loam will also be beneficial on the silt loam.

The valuation of the type, on an average, is a little higher than that of the Wabash loam.

Several small areas of Wabash silty clay loam have been included with the Wabash silt loam in mapping. In these areas the soil consists of an almost black silty clay loam surface soil, high in organic matter, and quite plastic when wet, which at an average depth of 16 to 18 inches becomes a heavy, poorly oxidized silty clay loam to silty clay, dark brown to black in color, with faint stains of yellowish brown, gray, and rusty brown in the lower subsoil. Lime carbonate is absent. The soil consists of material deposited by back waters or sluggish streams. The principal areas of this soil are in section 33 of Dale Township, sections 25 and 36 of Hartley Township, in Omega Township along Little Waterman Creek, and in Caledonia Township along Deep Creek. The topography is flat and depressed and the natural drainage is very poor. In its present condition this land is best suited for pasture.

SUMMARY.

O'Brien County is situated in the northwestern part of Iowa. It comprises an area of 569 square miles, or 364,160 acres.

A gently rolling plain of loess-covered drift characterizes all but the extreme eastern part of the county. In this eastern section the drift materials are exposed and are modified very little by loess. The uplands range in elevation from 1,375 to 1,550 feet above sea level. The drainage of the county is carried mainly by the Little Sioux, Ocheyedan, and Floyd Rivers and Mill and Waterman Creeks. Natural drainage varies from fair to good the county over.

O'Brien County was first settled in 1856 and organized in 1860. The population is predominantly native American.

Named in order of size the leading towns are Sheldon, Sanborn, Hartley, Paullina, Primghar, Sutherland, Calumet, Archer, and Moneta. Five railroads traverse the county, affording good transportation facilities.

The mean annual precipitation is 27.39 inches. The rainfall is usually well distributed throughout the growing season. The mean annual temperature is 45.7° F.

The farms of O'Brien County are well improved, and equipped generally with modern and efficient implements. A combined grain and stock farming system prevails. Corn, oats, barley, and wheat are the

grain crops most commonly grown. Timothy, clover, and some alfalfa are the common hay crops. Hog raising, cattle raising and fattening, dairying, sheep raising, and horse production are the livestock industries, named in order of importance.

Crop rotation, while generally recognized as advantageous is not generally practiced. Corn and small grains predominate, and the hay crops are crowded from their place in definite systems of rotation. Barnyard manure is the only fertilizer generally applied.

Farm laborers are fairly efficient and generally of a good class. Farms usually are of the so-called family size, averaging about 160 acres. Over half of the farms are operated by tenants.

Under market conditions in 1921 farm lands of the county had an average value of $250 to $275 an acre.

The soil materials are of glacial deposition modified in varying degrees by a surface deposit of loess. They have no relation to any underlying rock formations.

The loessial upland soils, mapped as the Marshall silt loam and its flat phase, occupy over 80 per cent of the upland of the county. The upland glacial-drift soils are mapped as the Clarion loam, steep phase, Clarion silt loam, Carrington silt loam, Webster silty clay loam, and Dickinson fine sandy loam. These upland soils comprise about 90 per cent of the area of the county.

The terrace soils are mapped as five types, two of which, the O'Neill loam and Sioux loam, have light gravelly subsoils and the other three have heavy subsoils. Of the latter the Fargo silty clay loam is the most extensive, the Waukesha silt loam and Judson loam ranking next in order. The combined area of these terrace soils comprises about 3 per cent of the area of the county.

The first-bottom lands comprise the remaining 7 per cent of the county, and are classed as the Lamoure loam and silty clay loam and the Wabash loam and silt loam. The Lamoure silty clay loam occupies the largest area of bottom land.

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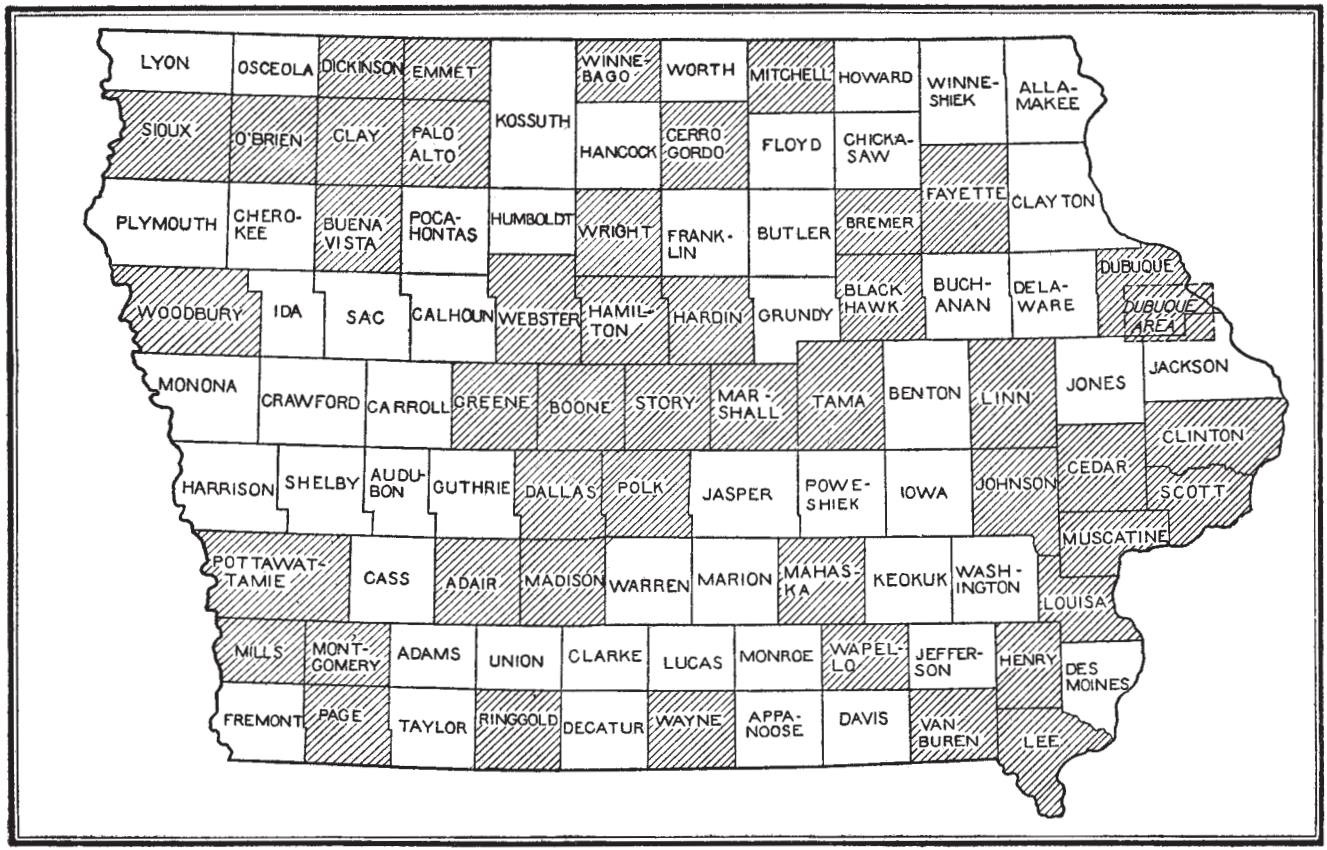

Areas surveyed in Iowa, shown by shading.

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